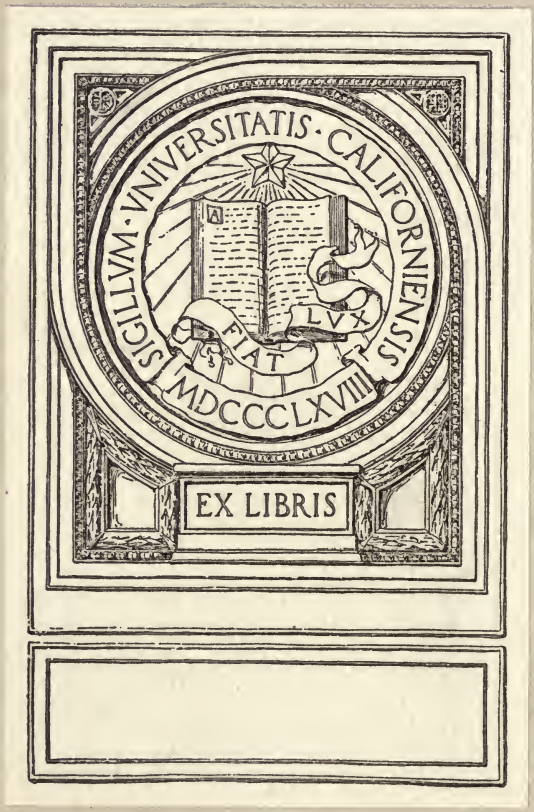
WEEDS OF FARM LAND

W. E. BRENCHLEY


SIGILLVM · VNIVERSITATIS · CALIFORNIENSIS
LVX
FIAT
MDCCCLXVIII
EX LIBRIS

WEEDS OF FARM LAND

UNIV. OF
CALIFORNIA

Fig. 31.—Red Bartsia (*Bartsia odontites*), parasitic on Wheat.

UNIV. OF CALIFORNIA

WEEDS OF FARM LAND

BY

WINIFRED E. BRENCHLEY, D.Sc., F.L.S.

FELLOW OF UNIVERSITY COLLEGE, LONDON
BOTANIST, ROTHAMSTED EXPERIMENTAL STATION

WITH ILLUSTRATIONS

LONGMANS, GREEN AND CO.
39 PATERNOSTER ROW, LONDON
FOURTH AVENUE & 30TH STREET, NEW YORK
BOMBAY, CALCUTTA, AND MADRAS
1920

UNIV. OF
CALIFORNIA

SB611
B7

6/13/22

PREFACE.

EVERYONE who cultivates the soil, whether on the farm or garden, is perforce interested in weeds, for their absence or presence amongst the crops has much to do in determining the relative success or failure of the undertaking. A very great deal has been written on the subject, but the information is widely scattered throughout the literature of agriculture and botany. In this country, at least, very few efforts have hitherto been made to gather up and correlate this varied knowledge, thus rendering it accessible to those most interested. Furthermore, it is only of recent years that definite attempts have been made to work out the quantitative and qualitative relations between weeds, the soils on which they grow and the crops with which they are associated. In this respect the conclusions so far drawn can only be regarded as tentative, subject to modification and revision as more data become available. It has seemed justifiable, therefore, to attempt to set forth the present position of affairs, in order that future attacks on the weed problem may be more co-ordinated, and that valuable time and labour may be utilised to the best advantage.

The original investigations embodied in the following pages owe much to the cordial assistance afforded by the many landowners and farmers whose land has been utilised for the purpose. It is impossible to record each individually, but my special thanks are due to Professor T. B. Wood, Mr. Spencer Pickering, Mr. E. S. Beaven, Mr. E. E. Stokes, and Mr. J. H. Burton, all

470438

of whom facilitated the work by giving me introductions throughout the districts with which they were best acquainted.

Miss M. B. Lee and Miss V. G. Jackson have rendered valuable assistance with the proof sheets, and, above all, I am specially indebted to Dr. E. J. Russell for his constant advice and criticism throughout the preparation of the book.

W. E. B.

ROTHAMSTED,
June, 1920.

CONTENTS.

PAGE

CHAPTER I.

INTRODUCTION - - - - - - - - - - - - - 1

CHAPTER II.

DISTRIBUTION OF WEEDS - - - - - - - - - - 10

CHAPTER III.

PREVENTION AND ERADICATION OF WEEDS - - - - - - - 43

CHAPTER IV.

VITALITY OF WEED SEEDS - - - - - - - - - - 72

CHAPTER V.

HABITS OF WEEDS - - - - - - - - - - - - 84

CHAPTER VI.

PARASITIC WEEDS - - - - - - - - - - - - 92

CHAPTER VII.

POISONOUS AND INJURIOUS WEEDS - - - - - - - - - 103

CHAPTER VIII.

ARABLE WEEDS. ASSOCIATION WITH SOILS. I. GENERAL - - - 117

CHAPTER IX.

ARABLE WEEDS. ASSOCIATION WITH SOILS. II. SPECIAL - - - 121

PAGE

CHAPTER X.

Arable Weeds. Association with Crops - - - - - - 159

CHAPTER XI.

Grassland Weeds - - - - - - - - - - - - 175

CHAPTER XII.

Uses of Weeds - - - - - - - - - - - - 187

CHAPTER XIII.

Popular and Local Names of Weeds - - - - - 206

LIST OF ILLUSTRATIONS.

FIG.

31. RED BARTSIA (*Bartsia odontites*), parasitic on Wheat - *Frontispiece*

PAGE

1. BLACK BENT (*Alopecurus agrestis*) - - - - - - - - 8
2. FAT HEN (*Chenopodium album*) - - - - - - - - 13
3. ORACHE (*Atriplex patula*) - - - - - - - - - 14
4. SPIKELET OF FRUITS OF WILD OAT (*Avena fatua*) - - - - 16
5. KNOTGRASS (*Polygonum aviculare*) - - - - - - - 19
6. FRUIT OF NARROW-LEAVED VETCH (*Vicia angustifolia*) - - - 21
7. A. WINGED SEED OF YELLOW RATTLE (*Rhinanthus crista-galli*) - 22
   B. WINGED SEED OF SPURRY (*Spergula arvensis*) - - - - 22
   C. WINGED FRUIT OF HOGWEED (*Heracleum sphondylium*) - - 22
   D. WINGED FRUIT OF BROAD-LEAVED DOCK (*Rumex obtusifolius*) - 22
8. PLUMED FRUITS—
   A. Coltsfoot (*Tussilago farfara*) - - - - - - - 24
   B. Creeping Thistle (*Cirsium arvense*) - - - - - - 24
   C. Hawkbit (*Leontodon hispidus*) - - - - - - - 24
   D. Dandelion (*Taraxacum vulgare*) - - - - - - 24
   E. Groundsel (*Senecio vulgaris*) - - - - - - - 24
   F. Goatsbeard (*Tragapogon pratensis*) - - - - - - 24
9. PLUMED SEEDS OF WILLOW-HERB (*Epilobium sp.*) - - - - 25
10. HOOKED FRUITS—
   A. Agrimony (*Agrimonia eupatoria*) - - - - - - 26
   B. Wild Carrot (*Daucus carota*) - - - - - - - 26
   C. Goosegrass (*Galium aparine*) - - - - - - - 26
   D. Corn Buttercup (*Ranunculus arvensis*) - - - - - 26
11. CORN BUTTERCUP (*Ranunculus arvensis*) - - - - - - 27
12. SHEPHERD'S NEEDLE (*Scandix pecten*) - - - - - - 28
13. BINDWEED (*Convolvulus arvensis*) - - - - - - - 29
14. CREEPING THISTLE (*Cirsium arvense*) - - - - - - 30
15. HORSETAIL (*Equisetum arvense*) - - - - - - - 31
16. COUCH-GRASS (*Agropyron repens*) - - - - - - - 32
17. CORN SOWTHISTLE (*Sonchus arvensis*) - - - - - - 33
18. COLTSFOOT (*Tussilago farfara*) - - - - - - - 34
19. WOODWAX (*Genista tinctoria*) - - - - - - - - 35
20. SORREL (*Rumex acetosa*) - - - - - - - - - 36

FIG.		PAGE
21.	Bulbous Buttercup (*Ranunculus bulbosus*)	37
22.	Mouse-ear Hawkweed (*Hieracium pilosella*)	39
23.	Creeping Buttercup (*Ranunculus repens*)	40
24.	Onion Couch (*Arrhenatherum avenaceum*)	41
25.	Seedling of Creeping Thistle (*Cirsium arvense*)	82
26.	Dodder (*Cuscuta trifolii*), parasitic on Clover	93
27.	Broomrape (*Orobanche minor*), parasitic on Sainfoin. Right.—Sainfoin plant not attacked. Left.—Sainfoin plant attacked by broomrape, showing the harmful effect on growth	*face* p. 96
28.	Broomrape (*Orobanche minor*), parasitic on Lucerne	
29.	Yellow Rattle (*Rhinanthus major*), parasitic on Oats	100
30.	Section across Barley Root Penetrated by Sucker of Yellow Rattle (*Rhinanthus major*)	101
32.	Autumn Crocus (*Colchicum autumnale*)	109
33.	Purging Flax (*Linum catharticum*)	109
34.	Crow Garlic (*Allium vineale*)	113
35.	Ramsons (*Allium ursinum*)	113
36.	Spurry (*Spergula arvensis*)	142
37.	Annual Knawel (*Scleranthus annuus*)	143
38.	Sheep's Sorrel (*Rumex acetosella*)	144
39.	Corn Marigold (*Chrysanthemum segetum*)	145
40.	Quaker-grass (*Briza media*)	180
41.	Plants common in trodden places—	
	A. Greater Plantain (*Plantago major*)	184
	B. Silverweed (*Potentilla anserina*)	184
	C. Rough-stalked Meadow-grass (*Poa trivialis*)	184

UNIV. OF CALIFORNIA

CHAPTER I.

INTRODUCTION.

It is impossible to begin to work land under any system of farming without immediately being confronted with the problem of weeds. Weeds are the inevitable corollaries of crops, and much of the science of farming consists in the skilful use of methods by which the weeds are kept in subjection. In the ordinary course of events all vacant land tends to clothe itself with vegetation, and soil that is artificially laid bare during farming operations offers a situation that is most favourable to the ingress of a native plant population. The farmer's crops are more or less alien to the areas on which they are grown, and consequently would have but little chance against the natural colonists if it were not for the assistance rendered by husbandry methods. Weeds have thus a very great practical and economic importance, and a right knowledge of their habits and distribution is a valuable asset. Every farmer has a general knowledge of the worst weeds that occur on his land, and usually knows how to deal with them, but comparatively few have that special knowledge of the individual weeds which is necessary if the more up-to-date and less-known methods of prevention and eradication are to be successfully applied. The farmers of this country are in possession of a vast amount of weed lore, and much information is scattered up and down agricultural literature, but hitherto very little attempt has been made to bring together the facts and so to correlate them that they form a complete whole, instead of being merely disjointed scraps of knowledge of local interest and value only. The field of inquiry is so large and the difficulty of obtaining the necessary mass of information so great that it is impossible to present anything like a perfect picture of the weed problem, but the aim of the present book is to sketch a preliminary outline from the facts that are already available, in the hope that at some future date it may be possible,

in the light of fuller knowledge, to fill in and to correct inaccuracies in the details.

Before beginning to discuss the problem in its general bearings it is essential that one should have a clear idea of the meaning of the term weed. The word is used very loosely, and under some circumstances is made to apply to almost any plant in any situation. For our purpose, however, it is essential to narrow the meaning down so that it bears an exact significance. British farm-land is worked on two distinct systems, according as the land is under the plough or laid down to grass. Generally both systems are combined, and a typical English farm consists of grass and arable land in proportions which vary according to the locality and to the individual needs of the farmer. The cropping under the two systems is radically different, as on the arable land the crop plants are fugitive and occupy the soil for a comparatively short season before they make way bodily for another crop, whereas on grass-land the plants are permanent, and retain their positions year after year, never being replaced by others unless the sward is ploughed up and a new crop sown. This difference in cropping has so great an influence upon the vegetation that covers the ground that it is necessary to have different definitions for the weeds of arable and grass-lands. On ploughed land a farmer desires only the crop from the seed he intends to sow, and anything else that appears on the field may be regarded as a weed. Consequently, a weed of arable land may be defined as "any plant other than the crop sown". On grass-land, on the contrary, a varied herbage is desirable, provided that the constituents of the herbage are of good nutritive value. Old pasture is usually clothed with a mixture of grasses, clover, and miscellaneous plants, which vary in proportion and in their value as food for stock whether as green fodder or as hay. Some of the grasses, such as Yorkshire fog, in some districts are almost useless or are positively harmful, whereas some of the miscellaneous plants such as rib-grass, are of high feeding value and in moderation are welcomed in the herbage. It is thus very difficult to say exactly what constitutes a weed of grass-land, but perhaps it may be defined as (*a*) "a plant of low feeding value," or (*b*) "a plant that grows so luxuriantly or plentifully that it chokes out other plants that possess more valuable nutritive properties".

Farmers regard the weeds of ploughed land and of grass-land from very different standpoints. Every agriculturist

will agree that alien plants among arable crops are pernicious and should be got rid of as far as possible. On the other hand, the weeds of grass-land are seldom considered to be of much significance, except when certain plants have specially noxious qualities which compel the farmers to take measures against them. For instance, buttercups are rarely eaten by stock if plenty of other food is available, and they simply encumber the ground when present in large quantities. Nevertheless, nothing is done to get rid of them and most people regard them with much tolerance, considering them merely as signs that the ground is particularly fertile where they grow luxuriantly. If, however, a little garlic, which taints milk, is present on grazing land strong measures are taken either to eradicate it or to ensure that milking cows do not have access to the fields. If the same relative quantities of buttercups and garlic were present on arable land, the buttercups would be even more harmful than the garlic in their action on the growth of the crop, and every effort would be made to rid the land of them. Generally speaking, arable weeds have the greater practical significance, and as a result much more information is available with regard to them than is the case with pasture weeds, so that it is possible to draw more definite conclusions as to their occurrence.

When land is well tilled the soil is constantly disturbed by such operations as ploughing, harrowing, and cultivating. After a crop is removed the soil is ploughed up, all vegetation growing on it is buried and much of it is killed. If seeds are buried in the soil they may germinate after the first ploughing, but they in their turn are destroyed by later ploughing or by the harrow and cultivator. If a cereal crop is grown the soil is left more or less undisturbed when once the young plants are well established, but if roots are wanted the land is kept cultivated the whole time the crop is on the ground. It is obvious that these conditions are not at all favourable to the persistence of weed plants unless they are so specially adapted to hold their own that they can be more or less indifferent to the rough treatment they get. For this reason the number of plant species that occur as weeds is limited, and even among this number there are very many which very seldom occur, except on particular soils or under special circumstances. There are few species that are really prevalent and widespread, and every one of these is markedly well adapted to the conditions of life. Furthermore, the weeds that are ubiquitous in

this country are chiefly cosmopolitan, and they either occur naturally under arable cultivation in other countries or they colonise rapidly if they are introduced. In parts of Australia the bush has been cleared comparatively recently and the land brought under cultivation. Where this has occurred the native flora has disappeared entirely, being unable to put up with the interference and the new conditions, but a weed flora has appeared composed of species that are common as weeds of cultivation in America and the Old World. The introduced species have adopted their new home to such an extent that they threaten to spread in a most injurious fashion, with the result that legislation has been brought to bear, and many of the more common species are proclaimed as noxious weeds. Among the proclaimed plants of Victoria State there are several that have been introduced from other parts of the world, and that are even more obnoxious in Australia than they are in this country, charlock, dodder, gorse, hemlock, and several varieties of thistles, as the milk and creeping thistles, being among the number.

A similar thing has happened in Canada. The list of Canadian Farm Weeds [1] consists chiefly of species that have been introduced from Europe, the native species being much less in evidence. Wild oat, dock, sheep's sorrel, spurry, chickweed, corn cockle, buttercup, shepherd's purse, charlock, clover, dodder, and ribgrass are but a few of the weeds that create as much trouble in Canada as they do in England, although they are not indigenous to that country but have been introduced in the course of cultivation. The same story is told by collections of weed seeds that have been sent to Rothamsted from Tasmania and the United States, and it is evident that certain species are so indifferent to the wide variation of soil and climate obtaining in different parts of the world that they will colonise and spread anywhere under conditions of cultivation.

From the early days of civilisation the weeds or alien plants that spring up among cultivated crops have attracted much attention because of the direct influence they exercise on the food supply of mankind. Methods of eradication have been advocated and tested, and the problem considered from every side, but in spite of all that has been done the weeds still flourish and menace the well-being of the crops at every turn. It is impossible to do away with weeds, for they are so well equipped for holding their ground and reproducing their

[1] Clark, G. H., and Fletcher, J. (1909), "Farm Weeds of Canada".

kind that no method of fighting them can ever be completely successful. The only thing is to circumvent them temporarily, keeping up a constant battle to prevent them getting the upper hand.

When a number of plants of either the same or dissimilar species are grown in association the individuals of the community act and react on one another and determine the ultimate nature of the plant association. The interaction between the species is very much affected by other factors such as moisture, sunlight, season, and interference by man, and under the specialised conditions of cultivation the interplay tends to become obscured to a great extent. When a large number of plants are growing in close association keen competition exists between them, and the weaker plants are apt to be smothered out, while the stronger continue to struggle on together. This competition takes place both below and above ground. The supply of moisture and available plant food is not inexhaustible, and if a large number of roots are drawing from the same area at the same time semi-starvation threatens the plants. Above ground there is usually an adequate supply of air and sunshine, but the vegetation is not always in a position to take full advantage of it. If the plants are closely crowded together the leaves overlap and shade one another, so that a large proportion of them cannot be reached by the sunlight, and in this way the assimilation of carbon-dioxide is hindered and the nutrition of the plants suffers accordingly. Respiration is probably influenced less adversely under these circumstances as the diffusion of the air carries an abundant supply of oxygen even to the shaded leaves, and light is not essential to breathing. The harmful effect of overcrowding is constantly to be seen in gardens. If a number of young seedlings are allowed to grow on too long in a crowded seed-box they become drawn up and delicate, and if left undisturbed die without making any satisfactory growth. Even if they are planted out they never make the same robust and healthy growth as do similar seedlings transplanted before the little plants have time to injure one another.

If the roots of the associated plants feed at different depths in the soil, as for instance in the case of wheat and poppy, the underground competition is far less severe, but the aerial competition is so strong that the plants may suffer as much as though all the roots were at the same level. Water culture experiments, in which each barley plant had its own individual

food supply, have shown how actively aerial competition comes into play quite independently of the root competition.[1] When the plants were grown at some distance from one another so that no shading occurred growth was strong and even, a large amount of dry matter being produced. When a number of plants were closely crowded together they were far less healthy, and the amount of dry matter formed by individual plants decreased as the amount of shading by neighbouring leaves increased. The crowded plants were unable to carry on adequate carbon assimilation owing to deficiency of light caused by the overlapping of leaves. As this decrease of growth occurred even when there was no lack of food for the individual plants it is obvious that aerial competition must play a still more important part in the field where the plants are competing for food as well as light. Many of the methods and processes of cultivation are directed towards the elimination of this competition of weeds with crops, the same end being attained by various systems of farming.

Under ordinary farm management the various crops are grown in rotation, one of the simplest being the four-course rotation, barley, seeds, wheat, roots. The seeds are sown down with barley in spring, and if germination is good the heavy growth of the barley tends to keep down weeds, while the clover manages to mark time until the barley is cleared off in the autumn. The habit of growth of the clover prevents the ordinary weeds from making much headway, although a number of special weeds are often introduced by this crop. Consequently, when the clover makes way for the wheat the land is not weed-ridden if the barley and clover have been good. The weeds have not had much chance to develop and to seed, and those introduced by the clover are not usually permanent. With the autumn-sown wheat the weeds get their chance. The seeds buried in the soil rush into growth, and the wheat crop is full of a great variety of weeds unless some proportion of them is removed by spring cultivation. Even so the wheat stubble is a veritable flower garden, and is full of many varieties of weeds ripening their seeds in readiness for the future. After such a fouling crop as wheat, therefore, roots follow on well, as they offer a good opportunity to clean the land and to improve the condition of the soil by cultivation, ready for the next cycle of crops.

[1] Brenchley, W. E. (1919), "Some Factors in Competition," *Journ. Applied Biology*, VI, Nos. 2 and 3, pp. 142-170.

Rather curious things happen if no rotation is followed, but the same crop is grown on the land year after year without intermission. Several fields at Rothamsted have been under continuous cropping for many years, and the differences in the weed floras are of the most striking nature. The fields are divided into plots which are manured in various ways, and the differences in manuring and the time of sowing the crops have a considerable influence upon the number and variety of the weeds. Broadbalk field at Rothamsted has carried autumn-sown wheat regularly since 1843, so that as soon as one crop is harvested it is necessary to plough up the stubble in preparation for sowing the next year's crop. Consequently, there is never any opportunity of thoroughly cleaning the ground by winter fallow, and as a wheat crop does not admit of much cultivation in the ordinary way, a very special state of affairs has risen with regard to the weeds. Black bent (*Alopecurus agrestis*) (which occurs to some extent on many fields in the district but not plentifully enough to cause any trouble) grows up with the corn and ripens its seeds at the same time as the wheat, so that harvesting operations tend to scatter the seed freely on the ground. (Fig. 1.) These seeds germinate at once, in the autumn, and the plants develop alongside the wheat, from which in their young stages they are not easily distinguished by casual observation. Under rotation farming the weed does not get a serious hold, as it is soon cleared out by the cultivation of barley and roots. On Broadbalk, however, no opportunity arises of ridding the ground of the young black bent plants before the wheat has to be sown, and with the lapse of years the pest has spread to such a great extent that it entails very great expense for hand labour to free the crop in order to prevent the experiments being spoiled. It is necessary to hoe out the rows in early summer, and in bad seasons to hand-pull the plants in order to remove as many as possible before they have a chance to seed. It is not at all uncommon for heaps of black bent 3 or 4 feet high to be removed from each plot of $\frac{1}{2}$ acre. The strong measures necessary for fighting this weed help to keep the others in check, so that no other species presents such a difficult problem.

The adjoining Hoos field has carried barley every year since 1852, but as the barley is spring sown the weed problem is far less acute. The time that elapses between harvesting in August or September and sowing in the spring is sufficiently

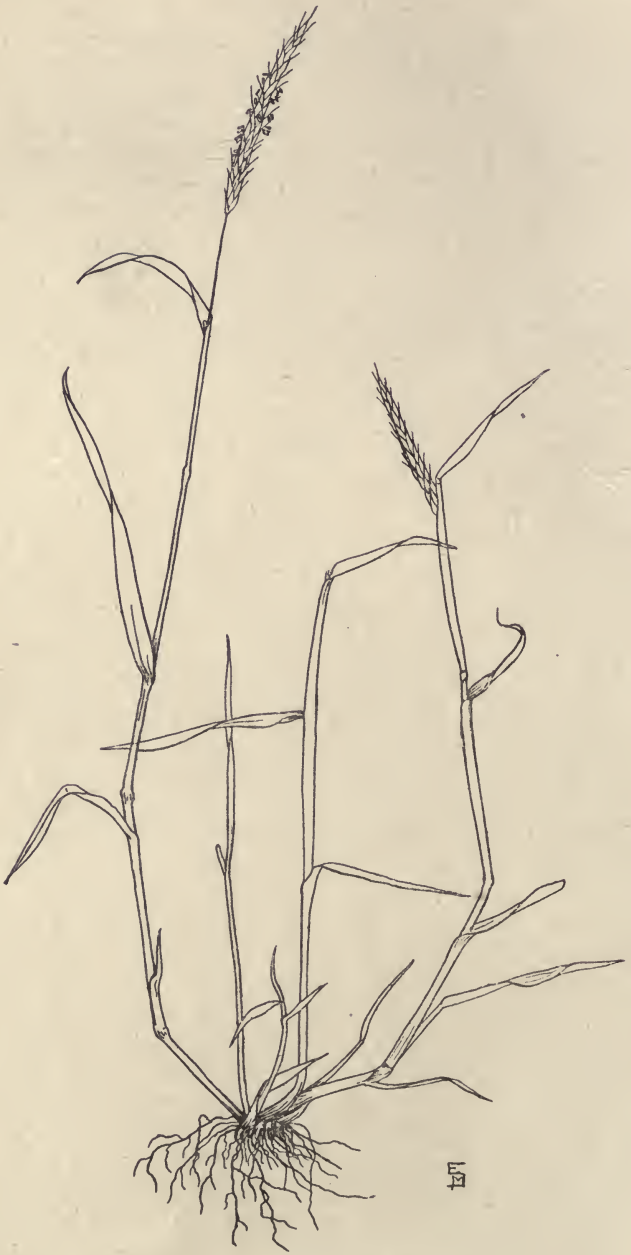


FIG. 1.—BLACK BENT (*Alopecurus agrestis*).

long to allow the land to be well worked over, so that no single weed has the opportunity of obtaining such a hold as black bent has on Broadbalk. At the present time, however, the perennial corn sowthistle (*Sonchus arvensis*) is causing much trouble in Hoos field, as it spreads by underground stems, and the broken pieces left after cultivation shoot up again with the barley.

In contrast to Broadbalk and Hoos, Barn field is devoted exclusively to root crops. Sugar beet used to be grown, but of late years mangolds have been taken instead. The field is remarkable for the poverty of its weed flora. At no time in the year do a large number of weeds occur, and the variety of species is small. Some chickweed and groundsel, a few creeping thistles and greater plantain, represent the major part of the weed population at any period of the year, and even after the winter, just previous to ploughing, the same thing is seen. The continuous growth of roots for so many years, with the attendant cultivating and hoeing, has cleared the land of most of the weed seeds which may have been originally buried in it, and has also prevented weed colonists from establishing themselves and shedding their seeds.

Many of the points touched on in this introduction will be dealt with more fully in later chapters, but enough has been said to indicate the vital importance of a right understanding of the weed problem if it is to be approached in such a way as to render profitable assistance to the farmer. With the improvements in agricultural machinery and the greater application of chemical knowledge to agriculture in the direction of manures and sprays, it is conceivable that it may be possible at no distant date to hold the weeds far more under control than has ever been the case in the past.

CHAPTER II.

DISTRIBUTION OF WEEDS.

THE flora of any country or district usually comprises many hundreds or thousands of species, but of these comparatively few are conspicuous as weeds of cultivation. This is to a very great extent determined by the fact that cultural conditions are inimical to the growth of many wild plants which resent interference with their normal conditions of life. The extent of the weed flora is further circumscribed by the fact that many plants, though able to withstand the conditions peculiar to cultivation, are so ill adapted to arrange for their own reproduction under the specialised circumstances that they fail to maintain their position and are therefore practically unknown as weeds. The most familiar and widespread weeds are those plants which are the best adapted to meet the difficulties which arise from the carrying on of the various operations of cultivation.

The methods of weed distribution are many and various, but may be broadly divided into two classes, though the dividing line cannot always be sharply maintained :—

(1) Methods which are independent of any special adaptations for distribution developed by the plants.

(2) Methods which are dependent upon special adaptations for distribution developed by the plants.

1. METHODS WHICH ARE INDEPENDENT OF ANY SPECIAL ADAPTATIONS FOR DISTRIBUTION DEVELOPED BY THE PLANTS.

(*a*) *Various Means of Transport, as in Cargoes, Ballast, etc., including the Transport of Impure Seed.*—Distribution by means of transport must be held accountable for the spread into various parts of the world of many of the worst weeds of cultivation. With the increase in trading facilities and the opening up of fresh shipping routes there has come a notable change

in the weed floras of many districts, and the difficulties of agriculturists have thereby in many cases been greatly augmented. As is shown below, weed seeds are transported from one country to another in various ways, and it frequently happens that a weed that is of little or no account in its country of origin finds the conditions of a foreign land so congenial that it spreads and becomes a veritable pest, often needing legislation for its suppression. Sometimes, too, with change in methods of cultivation, an alien weed flora may crowd out the native weeds more or less completely. In the settled portions of New Zealand and Australia,[1] where clearings have been made and introduced crops like wheat are grown, the alien weeds are most conspicuous and dominate the situation. Apparently the native plants are adversely affected by the interference due to the new methods of cultivation, and are unable to withstand the competition of the foreign plants of which the seeds are introduced with the crop seeds, and as a result the intruders have been able to gain a firm foothold. A considerable intrusion of Northern plants into the New Zealand flora has occurred. When a party of the British Association visited the country in 1914 much watercress was noted in one place, and in other localities *Geranium molle* and *G. robertianum* (the former a typical arable weed) were completely naturalised.

The extent to which weed seeds can be carried from one country to another in cargoes of grain and other crop seeds has been well shown by Stapledon,[2] who has proved that it is possible to trace the country from which samples of commercial oats have originated by means of the quantity and varieties of weed seeds that are present. For instance, oats from Russia usually contain an abundance of corn cockle, and wild vetches and field bindweed are also often plentiful. Turkey seed is characterised by the presence of a considerable amount of *Rapistrum rugosum*, an unidentified *Medicago*, and a fair quantity of darnel and sweet clovers; Canadian origin is shown by excess of ball mustard (*Neslia paniculata*) and by blue bur (*Lappula echinata*) and prairie sunflower, while in British seed black bindweed (*Polygonum convolvulus*) and charlock (*Brassica spp.*) are often the only weed seeds,

[1] Rendle, A. B. (1915), "The British Association in Australia," *Jour. Bot.*, LIII, No. 625, pp. 23-34.

[2] Stapledon, R. G. (1916), "Identification of the Country of Origin of Commercial Oats," *Jour. Bd. Agric.*, XXIII, No. 2, pp. 105-116.

though a wild oat (*Avena strigosa*) is sometimes met with. An examination of the Canadian weed flora is illuminating. Out of seventy of the worst agricultural weeds that are fully described and figured by the Department of Agriculture[1] forty-seven are characterised as being introduced from Europe, one from Asia, and one from Tropical America, only twenty-one being indigenous.

Weed seeds may be carried from country to country, not only among crop seeds, but also in ballast or with forage of various kinds. An analysis of the flora of an old ballast heap at Linnton, Oregon, on the Pacific coast, showed[2] thirty-two species indigenous on the Pacific coast, eighty-eight species introduced to the district but occurring elsewhere in Oregon, and ninety three species collected only on the Linnton ballast area and not found in other parts of the state.

Probably 50 per cent. of the list of species cited by Nelson have been collected for the first time on the Pacific coast, or at least within the limits of the State of Oregon. If information were available it would doubtless be found that a similar state of affairs exists in other places where ballast is dumped. In our own country much distribution is effected by the carriage of waste dust and rubbish by railway to dumps in various parts of the country. It is quite usual to find such dumps colonised by plants which are not native to the locality, but whose origin can be traced to the district from which the waste material was brought. It is probable that a good deal of weed distribution is effected in this manner, for if conditions are suitable an introduced plant will quickly establish itself and may become a troublesome pest.

(*b*) *Carriage in Manure.*—That weed seeds may be spread by manure from an infested district is a danger whose reality is too little recognised. If manure is stacked in a field for some time prior to use it rapidly becomes covered with weeds, among which fat hen (*Chenopodium album*) (Fig. 2) and orache (*Atriplex patula*) (Fig. 3) are often conspicuous. The seeds of these plants and many others are transported in the manure, which thus becomes a ready source of infestation. Only too often the litter used for bedding cattle contains much rubbish that is full of weed seeds, and unless excessive heating takes place many of these seeds retain their power of

[1] Clark, G. H., and Fletcher, J. (1909), "Farm Weeds of Canada".

[2] Nelson, J. C. (1917), "The Introduction of Foreign Weeds in Ballast, as illustrated by Ballast Plants at Linnton, Oregon," *Torreya*, XVII, pp. 151-160.

FIG. 2.—FAT HEN (*Chenopodium album*).

germination for a long period and are ready to start into growth when they are dug into the soil with the manure. Little is known about the amount of heating that weed seeds can withstand when buried in manure, but it is certain that under the ordinary conditions of making and storing dung large quantities of seeds escape destruction. If it can be avoided,

FIG. 3.—ORACHE (*Atriplex patula*).

therefore, it is best not to spread manure as soon as it is received from any district known to be badly infested with weeds. If the manure can be properly stored for some time, there is a possibility that many of the seeds will rot and that many others will take advantage of the genial warmth to start germinating, only to perish from the adverse conditions for plant life that exist within the heap.

The danger of weed transport in manure is probably less nowadays than it used to be, as with the improvement in threshing tackle a much cleaner separation of grain, straw and rubbish is effected, and the practice of burning the rubbish (containing most of the weed seeds) is becoming more widely spread. Also there is comparatively little transport of manure from one country district to another, but where stable manure is brought from towns much care should be exercised, as the litter and feeding stuffs are more likely to be contaminated with weed seeds than in the case of manure produced on farms.

(*c*) *Distribution by Means of Farm Implements.*—With the increase in the use of farm machinery of late years the danger of weed infestation from this source has become more acute. Almost every implement that is used in farm operations may serve as a carrier of seeds or growing parts of weeds, but as hand implements and the smaller horse machines are usually the property of the farm, weed distribution by this means is localised. With the advent of peripatetic tractors, threshing machines, reapers and binders, etc., the area of distribution was at once widened, and now care is necessary to prevent trouble arising. Farm implements spread weeds in various ways, the most obvious being by means of the clods of earth that are carried about on the wheels and on the horses' hoofs. The soil is full of weed seeds and in many cases broken pieces of weed are also present which are capable of striking root elsewhere. If machinery passes from farm to farm over a wide area, from badly-tilled farms to well-cultivated ones, the efforts of careful farmers to reduce their weed population may be greatly hindered if they do not take care that the incoming machines are well cleaned before they are allowed to pass on to the land. Threshing machines introduce another problem, as weed seeds collect within them, only to pass out when further threshing is carried out. Such weeds as wild oats (*Avena fatua*) are particularly troublesome in this way, as not only are they bad weeds on the land, but the hairy fruits with their bent and twisted awns collect in balls and rapidly choke up the machine (Fig. 4). Here again scrupulous care in cleaning before use is necessary if weed distribution is to be avoided.

(*d*) *Carriage by Moisture or in Mud.*—Though to some extent mud carriage is dealt with under the preceding heading other aspects must be considered here. Traffic of every kind

helps to distribute weeds, as mud containing the seeds is carried about on the feet of stock, cartwheels, boots of human beings, walking sticks, and in various other ways. This is often well shown along cart tracks or round gateways through which much traffic passes, as an assemblage of weeds characteristic of different situations may often be found there. For instance, the trampled mud round a single gate between a public road and a ploughed field on chalky Boulder clay was colonised by[1]:—

FIG. 4.—SPIKELET OF FRUITS OF WILD OAT (*Avena fatua*), showing the hairs and the twisted awns.

(1) *Arable Weeds* (from field).—Slender foxtail, scarlet pimpernel, charlock, fat hen, dwarf spurge, knotgrass, groundsel, field speedwell.

(2) *Grass-land Plants* (from grass by roadside). — Ryegrass, cat's-tail, greater plantain, broad-leaved dock, couchgrass.

(3) *Weeds found in both Situations.*— Silverweed and creeping thistle.

Traffic over such an area in muddy weather would be a constant means of weed distribution. It can easily be understood that mud containing weed seeds may be transported for very long distances when it is carried on the feet of animals or on the boots of men travelling by train or motor. On the whole it is the arable weeds that are chiefly distributed in this way, as roadside weeds usually have more specialised arrangements. The carriage of mud on cartwheels is often responsible for the temporary appearance of arable weeds in grass fields, as such plants as shepherd's purse, swinecress, chamomile, mayweed, spurry, and poppies will all spring up along wheel tracks across grass, though they rarely persist for more than one season unless the grass is obliterated and bare soil conditions prevail.

The spread of weeds by "damp carriage" is rarely recognised, but many seeds will adhere to damp boots or clothing where there is an entire absence of mud. Groundsel, ragwort, hawkbit, daisy, buttercup, dandelion, mouse-ear chickweed, and the seeds of various grasses may all be collected and transferred

[1] Woodruffe Peacock, E. A. (1918), "The Means of Plant Dispersal: Moisture and Mud Carriage," *Selborne Magazine*, XXIX, No. 338, pp. 20-22.

from grassy areas, while forget-me-not, field speedwell, fool's parsley, and persicaria are among the arable weeds that have been observed to be distributed in this way. Many weed seeds are rather sticky when damp and tend to adhere closely to anything they touch, so that they are easily carried about from one place to another.

(*e*) *Distribution by High Winds and Storm Columns.*—Very little seems to be known on this subject, but one observer, Woodruffe Peacock, has specially studied the point,[1] and his results suggest that this is a far more important means of distribution than is generally recognised. Ordinary wind drift will carry seeds some distance, but this is very local. Woodruffe Peacock cites a case of such distribution of charlock recorded in Thompson's "History of Boston," and if this could be more universally established it might throw some light on the continual appearance of charlock when grass land is ploughed up, or old arable land free from the weed is ploughed more deeply. Seeds of mithridate mustard (*Thlaspi arvense*) in Cadney (Lincs) were carried by a single spring gale over half a mile of arable peat. Whirlwinds or small local storm columns will lift and shift seeds for distances up to 150 yards, but storm columns can carry materials for miles. Distribution over an area of at least twenty-five miles has been observed in Lincolnshire. In 1897 a storm column brought to Cadney a variety of plants for which the nearest habitat was twenty to twenty-five miles away. Among these were wild onion (*Allium vineale*) and couch grass, while heavy plants of tufted vetch (*Vicia cracca*), including the root, were also carried. A list of the plants that Woodruffe Peacock has personally noted to be carried by storm columns in this country may be interesting, as so little information on the point is available:—

Many grasses.
Achillea millefolium (yarrow). Cut fragments.
Allium vineale (wild onion). Rooted plants.
Anthriscus sylvestris (wild chervil). Fragments.
Capsella bursa-pastoris (shepherd's purse). Rooted plants.
Cerastium vulgatum (mouse-ear chickweed). Rooted plants.
Hippocrepis comosa (horse-shoe vetch). Rooted plants.
Leontodon autumnalis (autumnal hawkbit). Cut fragments.
Lotus corniculatus (bird's foot trefoil). Rooted plants.

[1] Woodruffe Peacock, E. A. (1917), "The Means of Plant Dispersal," *Selborne Magazine*, XXVIII, pp. 40-44.

Ononis repens (restharrow). Broken pieces.
Rhinanthus crista-galli (yellow rattle). Cut fragments and rooted plants.
Rumex acetosella (sheep's sorrel). Cut fragments.
Stellaria media (chickweed). Rooted plants.
Vicia cracca (tufted vetch). Fragments.

Further observation on this means of dispersal are very desirable. Many weeds that are obviously distributed by means of seeds have apparently no special adaptation for dispersal, and yet there is no doubt that distribution does occur. It is quite possible that all the agencies at work are not fully known, and that wind carriage during gales and storm columns is of far more importance than is at present believed.

2. Methods which are Dependent upon Special Adaptations for Distribution Developed by the Plants.

Weeds having special adaptations that assist in their distribution may be broadly divided into two classes according as they are spread by means of

A. fruits and seeds (sexual reproduction).
B. vegetative parts (vegetative reproduction).

The line of division is not always sharply marked, as in some weeds both types of reproduction are well developed, but as a general rule only one method is of real importance to a particular plant. Those in which both methods are conspicuous comprise some of the worst of our agricultural weeds, as methods of eradication that are directed against the formation of seed are not always effective against the spread of vegetative parts and vice versa. This double-barrelled reproduction is specially noteworthy in thistles, wild onion, corn sowthistle, coltsfoot, and creeping buttercup, though it occurs to some extent in various other weeds. In the following classification the same weed may appear twice if the two methods of distribution are sufficiently well marked to warrant it.

A. Distribution by Fruits and Seeds (Sexual Reproduction).

(*a*) *Seeds Produced in Large Quantities.*—Many weeds that do not have special adaptations for seed distribution are safeguarded by the production of large quantities of seeds, so

many being formed that even if a very large percentage is lost or destroyed the surviving minority will be amply sufficient to provide an abundance of descendants. This method is very common and effective among arable weeds, especially with those which grow close to the ground. The various processes of cultivation are all inimical to the survival of weeds; when the seeds germinate the seedlings are liable to be ruthlessly cut down at various stages of growth. Under these circumstances the presence of large quantities of seeds in the

FIG. 5.—KNOTGRASS (*Polygonum aviculare*).

soil is most favourable for the weeds as the seeds do not all germinate at once, so that if and when the first batch of seedlings is destroyed, a fresh batch which may have more chance of reaching maturity springs up at short notice. This may be continued time after time, as seeds from one crop of weeds usually vary greatly in the time that elapses before germination, the period sometimes ranging from a few days to several years. Scarlet pimpernel, knotgrass (Fig. 5), mouse-ear chickweed, spurry, chickweed, and speedwells of various species are all low growing arable weeds which form such an abundance of seed that when once they are established it is

difficult to get rid of them. They spread over the surface of the ground with their long trailing branches, form flowers and fruits in rapid succession along the stems, and drop their seeds, which are usually several in a fruit, directly into the soil when they are ripe.

Charlock (*Brassica spp.*) produces an abundance of heavy seeds which to all appearance have no ready means of distribution other than that of falling into the soil in the neighbourhood of the mother plant. The true method of charlock distribution, however, is still a mystery, as it has a habit of turning up in profusion in all sorts of places at a distance from the nearest source of the seed.

Dodder (*Cuscuta spp.*) is little other than a seedbox, as its clusters of small flowers, ranged at frequent intervals along the twining stems, give rise to multitudes of seeds which either fall into the soil in the immediate vicinity or are carried away when the crop is cut, only to start a fresh infestation of the parasite elsewhere.

A certain number of taller and more upright weeds also form quantities of seeds, but these are usually so small and light that they are easily carried about by the wind; consequently their range of distribution is less limited, and the danger of loss when they are carried away is compensated for by their abundance. Shepherd's purse, toadrush (*Juncus bufonius*), broomrape (*Orobanche spp.*), and poppies are good examples, and in some cases, as poppy, the seed capsules have adaptations which prevent the escape of the seed in unsuitable weather when there is danger of it becoming damp and clogged.

(*b*) *Seeds Shot Out.*—A limited number of plants take a very active share in their own distribution by shooting the ripe seeds out to various distances. Crane's-bill (*Geranium spp.*) and stork's-bill (*Erodium spp.*), which are often present in temporary pastures, have a fruit consisting of five pieces or carpels joined to a central column, one seed being present in each carpel at the base. When the seeds are ripe, some amount of desiccation occurs, the carpels break away suddenly at the base and roll up backwards, jerking the seeds out as they go. The fruit of vetch (*Vicia spp.*) (Fig. 6) is a pod containing one row of seeds. When ripe the pod splits up both sides and curls suddenly into a spiral, shooting the seeds for some considerable distance, often several feet. In the spurges (*Euphorbia spp.*) the seeds are jerked away when ripe with considerable force.

This method of seed distribution is highly specialised, but is less effective than others. Comparatively few seeds are formed, and as the risk of life is very great it seldom happens that weeds of this description are very abundant. The geraniums are usually associated with temporary pastures, because when once the seed is sown there is little cultural interference and the weeds are able to ripen seeds in peace. If the ley is succeeded by tillage crops such as cereals or roots, the geraniums usually disappear rapidly, as there are not enough seeds in the soil to withstand the processes of cultivation.

(*c*) *Fruits and Seeds Distributed by Wind.*—Adaptations for this purpose are exceedingly common and are usually in the form of wings or hairs arranged to form a kind of parachute. The wings or hairs may be developed either on the seed itself or on the fruit, the latter being more general. Many of the seeds are liable to be lost, but they are produced in large quantities and under favourable circumstances can be carried for many miles. It is on this account that weeds with these adaptations are so peculiarly dangerous, for if they are allowed to ripen their seeds it is impossible to confine them within bounds, and a single dirty farm may vitiate all attempts at clean farming over a wide area.

FIG. 6. — FRUIT OF NARROW-LEAVED VETCH (*Vicia angustifolia*), showing one pod split open and curled back with the seeds shot out.

(*a*) *Winged Fruits.*—The winged part may either be firmly attached to the fruit or may be easily detachable. In several of the Umbellifers, as for instance hogweed (*Heracleum sphondylium*) (Fig. 7 C), a very broad wing is developed by the seed case, which encloses a single flattened seed. In the docks and sorrels the floating organ is formed by the persistent floral envelope or perianth, within which is the hard triangular fruit (Fig. 7 D).

(*β*) *Winged Seeds.*—In toadflax (*Linaria vulgaris*) and yellow rattle (*Rhinanthus crista-galli*) (Fig. 7 A) each seed is provided with a broad wing, so that it is easily carried by the wind. In some other cases, as in spurry (Fig. 7 B), a very

narrow wing is developed, but this is so small in proportion

FIG. 7.—WINGED SEEDS AND FRUITS.

A. Winged Seed of Yellow Rattle (*Rhinanthus crista-galli*).
B. Winged Seed of Spurry (*Spergula arvensis*).
C. Winged Fruit of Hogweed (*Heracleum Sphondylium*). Wing developed from Fruit Coat.
D. Winged Fruit of Broad-leaved Dock (*Rumex obtusifolius*). Wing consists of persistent Perianth.
(The small sketches are natural size.)

to the size of the seed that it is doubtful if it is an effective agent in distribution.

(γ) *Plumed Fruits.*—By far the greatest number of wind-carried weeds are provided with this type of mechanism, and the great majority, if not all, belong to one order of plants, the Compositæ. The Compositæ, world-wide in distribution and outstanding in number of species and in the multitude of individuals, most probably owe much of their pre-eminence to the fact that they have developed a thoroughly efficient method of distributing their seeds. The plumed fruits vary in size, some being quite tiny while others are comparatively large and heavy, but all agree in having the calyx, or outer floral envelope modified into a number of hairs called the pappus. These hairs radiate from a common centre, sometimes rising directly from the top of the fruit (as in groundsel and coltsfoot), sometimes being raised above the fruit on a slender beak, as in dandelion and goatsbeard. There is great variation in the type of hairs, for in some cases they are short bristles, as in hardhead; in others they are quite simple but long and silky, as in groundsel; in others they are feathered, as in creeping thistle, and yet again the hairs may be outstanding and interlacing so as to form a kind of web, as is well seen in goatsbeard. Among the common weeds that possess plumed fruits may be mentioned thistles (*Cirsium arvense* (Fig. 8 B), *C. lanceolatum*, *Carduus nutans*, etc.), cudweeds (*Filago germanica* and *Gnaphalium uliginosum*), groundsel (*Senecio vulgaris*) (Fig. 8 E), sowthistle (*Sonchus arvensis* and *S. oleraceus*), dandelion (*Taraxacum vulgare*) (Fig. 8 D), goatsbeard (*Tragopogon pratensis*) (Fig. 8 F), coltsfoot (*Tussilago farfara*) (Fig. 8 A), hawksbeard (*Crepis spp.*), mouse-ear hawkweed (*Hieracium pilosella*), hawkbit (*Leontodon spp.*) (Fig. 8 C). The common hardhead (*Centaurea nigra*) has only short scaly bristles, sometimes mixed with a few longer ones, but the greater knapweed (*C. scabiosa*) is crowned with a pappus of stiff hairs almost as long as the fruit itself.

(δ) *Plumed Seeds.*—Comparatively few plants are provided with plumed seeds, the only outstanding instances among British weeds being the willow-herbs (*Epilobium spp.*) (Fig. 9). The fruit is long and narrow and when ripe splits into four pieces which curl back and liberate the numerous small seeds, each of which bears a tuft of hairs.

(*d*) *Fruits and Seeds Distributed by Animals and Human Beings.*—Two distinct methods of distribution are included under this heading, in one of which the fruits and seeds attach

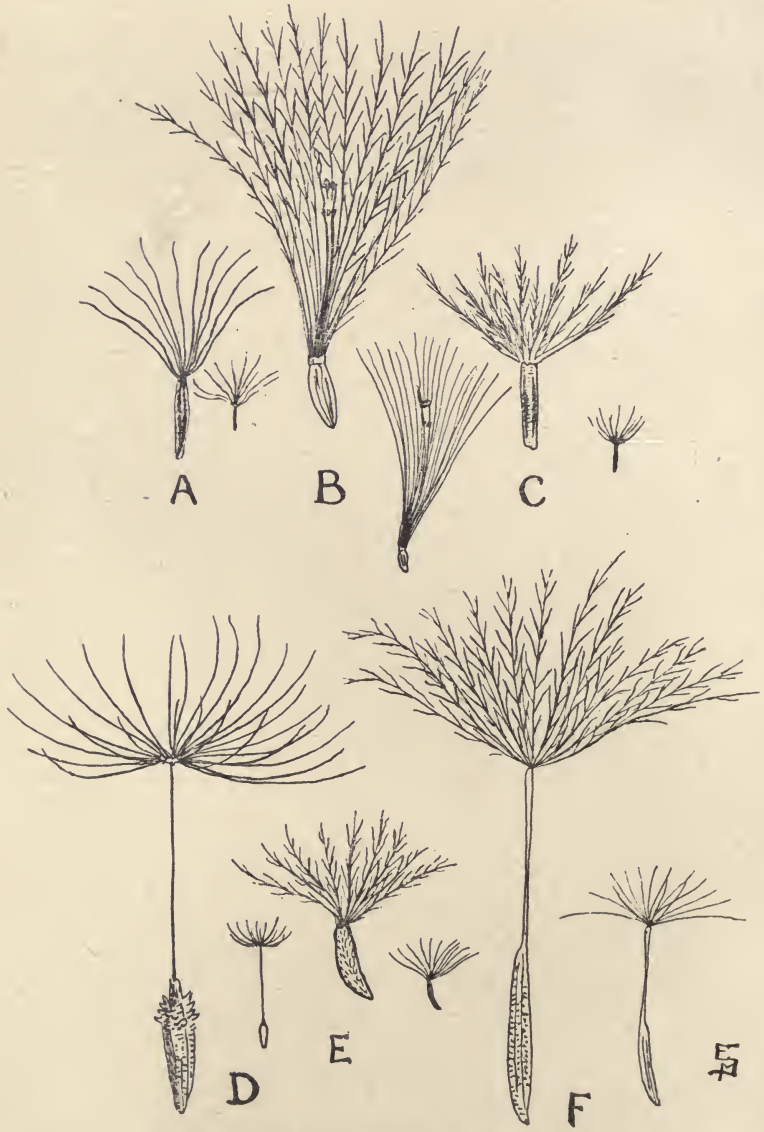


FIG. 8.—PLUMED FRUITS.

A. Coltsfoot (*Tussilago farfara*).
B. Creeping Thistle (*Cirsium arvense*).
C. Hawkbit (*Leontodon hispidus*).
D. Dandelion (*Taraxacum vulgare*).
E. Groundsel (*Senecio vulgaris*).
F. Goatsbeard (*Tragopogon pratensis*).

(The small sketches are natural size.)

themselves mechanically to the active distributing agent, and in the other are swallowed with the food and are ejected uninjured after passing through the body of the animal.

The fruits of agrimony (Fig. 10 A), wild carrot (Fig. 10 B), goosegrass (Fig. 10 C) and corn buttercup (Fig. 10 D and Fig. 11) are all provided with hooks of various types which catch on to the wool or hair of animals that pass

FIG. 9.—PLUMED SEEDS OF WILLOW-HERB (*Epilobium sp.*).

A. Fruit split open, showing Seeds.
B. Single Seed, natural size, showing Plume.
C. Seeds, enlarged.

amongst them, or on to the clothing of human beings. Shepherd's needle (Fig. 12) has less obvious hooks, but the fruits are distinctly rough and are well able to cling. The bent awn and numerous hairs of wild oat (*Avena fatua*) aid in its distribution by animals, and it is possible that the hygroscopic character of the awn, which twists and untwists according to the dampness of the air, may also play a part in the spread of this weed.

A considerable amount of seed distribution is probably carried out unconsciously by human beings, as seeds of many kinds of wild plants have a habit of working their way into pockets and folds of the clothes. The following weed and grass

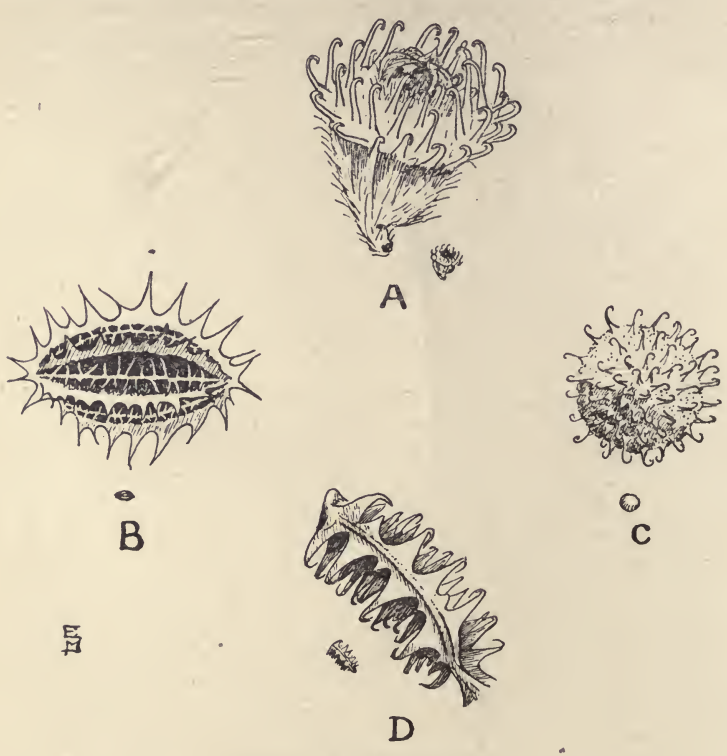


FIG. 10.—HOOKED FRUITS.

A. Agrimony (*Agrimonia eupatoria*).
B. Wild Carrot (*Daucus carota*).
C. Goosegrass (*Galium aparine*).
D. Corn Buttercup (*Ranunculus arvensis*).

seeds have all been collected from human clothing [1] and give a good idea of the diversity of species that may thus be spread. Avens (*Geum urbanum*), buttercup (*Ranunculus bulbosus* and *R. acris*), cocksfoot, couch grass, dandelion (*Taraxacum vulgare*), dock (*Rumex sanguineus*), enchanter's nightshade

[1] I am indebted to the Rev. E. A. Woodruffe Peacock for the loan of tubes containing seeds, etc., collected from human clothing. The above list is drawn up from the identifications thus obtained.

(*Circæa lutetiana*), forget-me-not (*Myosotis arvensis*), foxtail (*Alopecurus pratensis*), goosegrass (*Galium aparine*), hogweed,

FIG. 11.—CORN BUTTERCUP (*Ranunculus arvensis*), showing Flowers and Clusters of Fruits.

sterile brome (*Bromus sterilis*), tall fescue (*Festuca elatior*), tall oat (*Arrhenatherum avenaceum*), wall barley (*Hordeum murinum*), yellow oat (*Avena flavescens*), Yorkshire fog.

Experiments have shown that large numbers of weed seeds retain their power of germination and growth even after they have passed through the digestive tracts of animals (see p. 74). As animals often traverse long distances in a comparatively short time they are able in this way to accomplish a good deal of seed distribution, and may on occasion be responsible for the introduction of a weed into a fresh locality.

Fig. 12.—Shepherd's Needle (*Scandix pecten*), showing the Small Flowers and much Elongated Fruits.

(*e*) *Fruits and Seeds Distributed by Birds.*—Birds may either carry seeds about on their feet, feathers or bills, or they may eat them for food and void a certain proportion uninjured. Ducks, water hens, and other birds have been proved to carry species of water plants from one piece of water to another by means of wet seeds or pieces of the actual plant sticking to them. Creeping buttercup (*Ranunculus repens*) often occurs on the damp edges of ponds and is known to be carried about by ducks and water hens.[1]

Enormous numbers of weed seeds are eaten by wild birds, and though it is usually assumed that all such seeds are destroyed this is not the case. Collinge's [2] [3] experiments have shown that birds are in this way responsible for the distribution of many common weeds, including ribwort plantain, mouse-ear chickweed, groundsel, sheep's sorrel, daisy, yarrow, creeping buttercup, dandelion, chickweed, charlock, dock, knotgrass, goosegrass, and various others. From the

[1] Woodruffe Peacock, E. A. (1917), "Means of Plant Dispersal," *Selborne Magazine*, XXVIII, pp. 80-83, 97-101, 114-116; (1918), XXIX, pp. 9-12.

[2] Collinge, W. E. (1913), "Destruction and Dispersal of Weed Seeds by Wild Birds," *Journ. Bd. Agric.*, XX, pp. 15-26.

[3] Collinge, W. E. (1914), "Some Further Observations on the Dispersal of Weed Seeds by Wild Birds," *Journ. Econ. Biology*, IX, pp. 69-71.

results of these experiments it is probable that seed-eating birds are far more active as distributors of weed seeds than is usually

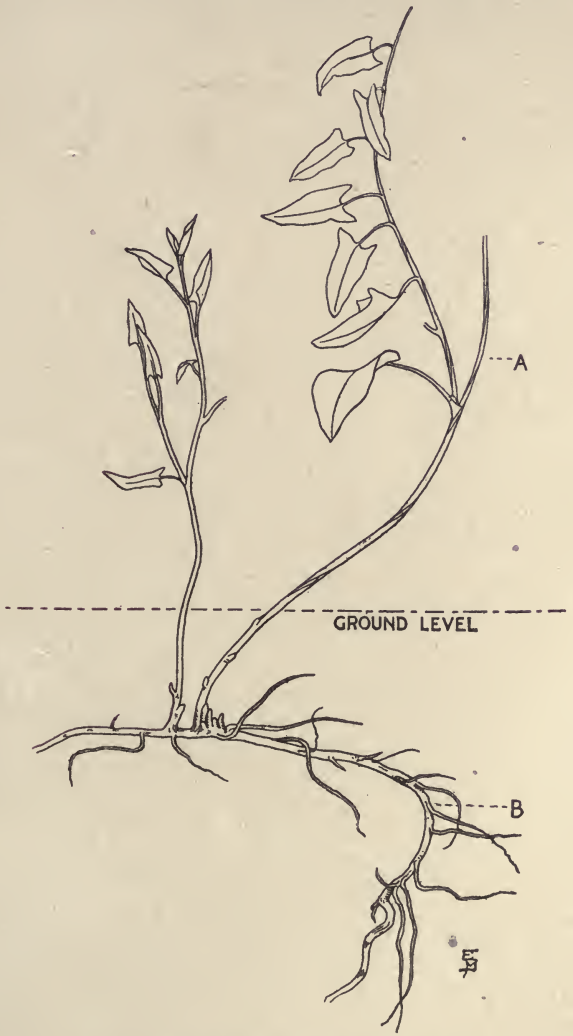


FIG. 13.—BINDWEED (*Convolvulus arvensis*).
A. Aerial Shoot. B. Underground Stem.

imagined. Evershed examined many pheasant crops [1] and

[1] Evershed, A. F. C. H. (1918), "Pheasants and Agriculture," *Journ. Ag. Sci.*, IX, pp. 63-91.

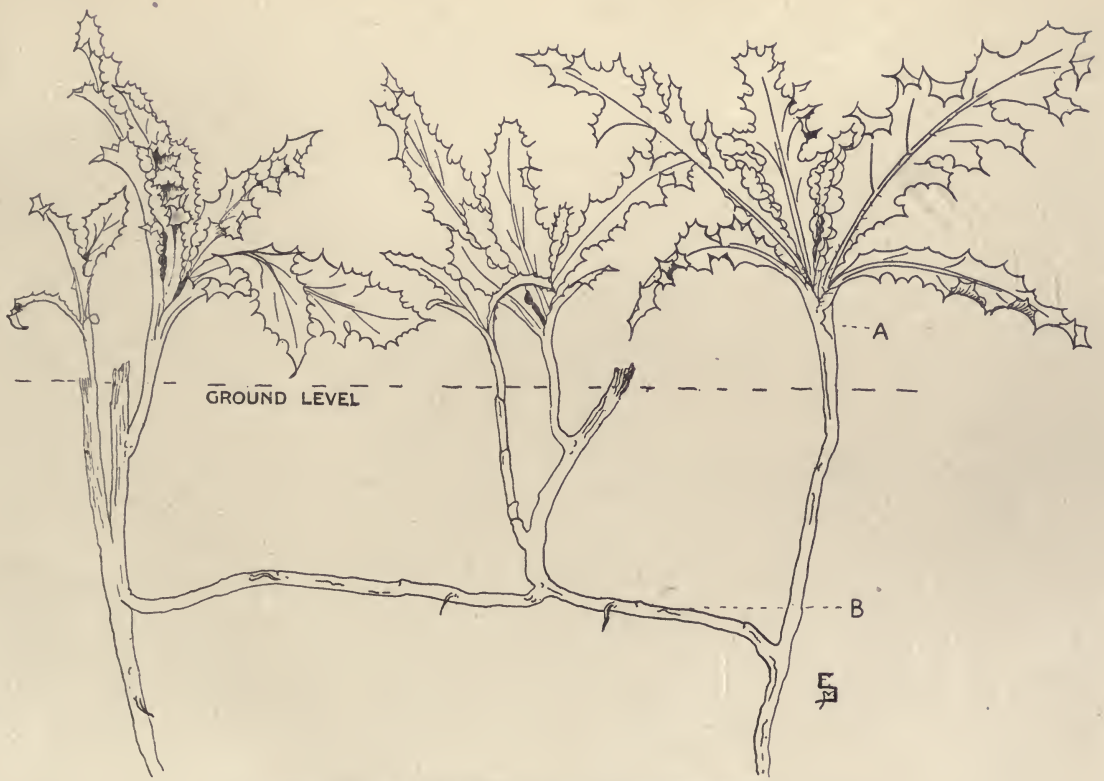


FIG. 14.—CREEPING THISTLE (*Cirsium arvense*).
A. Aerial Shoot. B. Creeping Underground Stem, with small Rootlets.

found large numbers of weed seeds therein. In some cases hundreds or thousands of seeds of one species were present in a single crop, and if even a small percentage of these passed unharmed through the bird a great deal of weed distribution would be effected. The most abundant seeds were those of fat hen, knotgrass, bindweed, field pansy, persecaria, chickweed and buttercup, but in addition speedwell, goosegrass, plantain, black bindweed, spurry, sandwort, scarlet pimpernel, toadflax, and mayweed were well represented, and a few seeds of several other species were also present. In a few weeds, as bittersweet (*Solanum dulcamara*) and black nightshade (*S. nigrum*), seed distribution by birds is ensured by special attractions, the seeds being enclosed in juicy coloured berries which are eagerly devoured, and many later ejected uninjured, the weeds thus being spread far and wide.

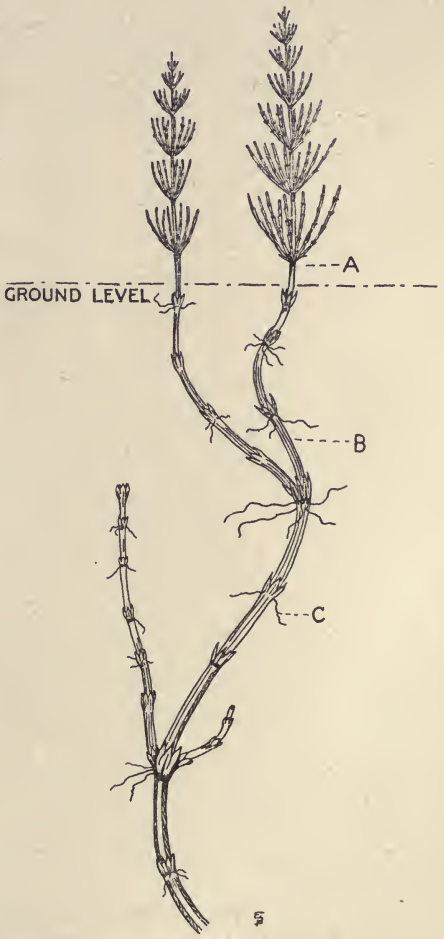


FIG. 15.—HORSETAIL (*Equisetum arvense*).
A. Aerial Shoot. B. Underground Stem.
C. Rootlets.

B. Distribution by Vegetative Parts (Vegetative Reproduction).

(*a*) *By Underground Stems.*

(*a*) *Creeping Stems.*—Some of the weeds that are most difficult to eradicate are provided with elongated branching

stems that creep along below the surface of the ground. These stems do not bear ordinary leaves but are usually clothed with thin colourless or brown scale leaves from whose

FIG. 16.—COUCH-GRASS (*Agropyron repens*).
A. Aerial Shoot. B. Creeping underground Stem. C. Sharp-pointed Bud on Underground Stem.

axils branches arise that grow up above the soil and develop the usual type of green leaves. The underground stems serve as carriers whereby the new aerial shoots are taken to a considerable distance from the original position, so extending the

FIG. 17.—CORN SOWTHISTLE (*Sonchus arvensis*).

A. Aerial Shoot.
B. Creeping Underground Stem.
C. Rootlets.
D. Flower-head.

FIG. 18.—COLTSFOOT (*Tussilago farfara*).

A. Aerial Shoot. B. Creeping Underground Stem. C. Bud from Underground Stem which will develop into an Aerial Shoot.

FIG. 19.—WOODWAX (*Genista tinctoria*).
A, Aerial Shoot, B, Stout woody Underground Stem.

range of the weed. Rootlets are given off from the creeping stems, and if the latter are broken up every small piece that bears a bud or young shoot is capable of striking root for itself

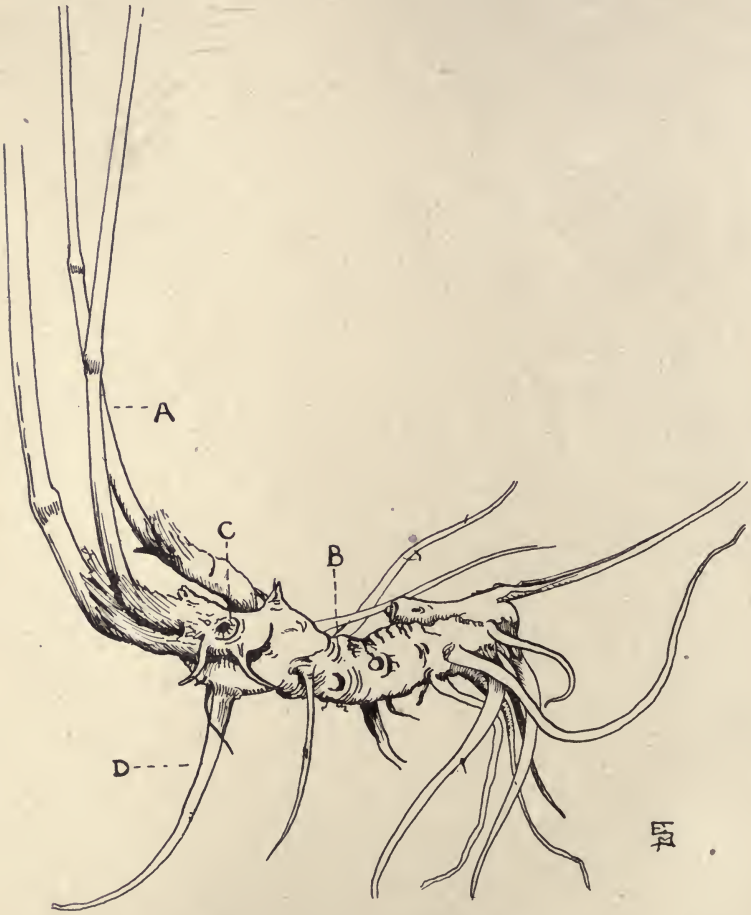


FIG. 20.—SORREL (*Rumex acetosa*).

A. Aerial Shoot.
B. Thickened Underground Stem.
C. Scars of old Aerial Shoots.
D. Roots.

and forming an independent plant. In bindweed (*Convolvulus arvensis*) (Fig. 13), thistle (*Cirsium arvense*) (Fig. 14), horsetail (*Equisetum arvense*) (Fig. 15), couchgrass (*Agropyron repens*) (Fig. 16), and sheep's sorrel (*Rumex acetosella*) (Fig. 38), the underground stem is fairly thin, but in corn sowthistle

(*Sonchus arvensis*) (Fig. 17) it is much stouter, while in coltsfoot (*Tussilago farfara*) (Fig. 18) it is sometimes as thick as a finger, rather fleshy, and may strike down several feet into the soil, and then turn horizontally instead of creeping just below the surface.[1] As branches are sent up at frequent intervals a

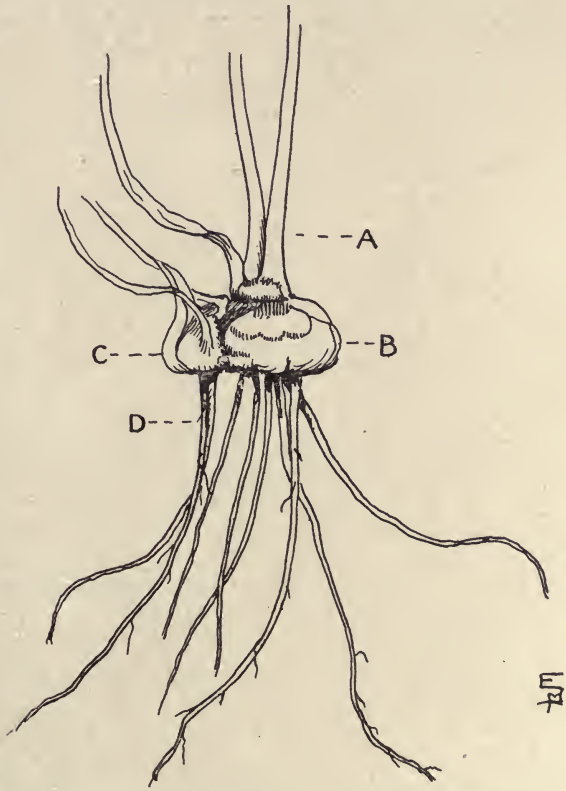


FIG. 21.—BULBOUS BUTTERCUP (*Ranunculus bulbosus*).

A. Aerial Shoot.
B. Swollen Base of Stem.
C. Bud from which new Plant will arise.
D. Roots.

single coltsfoot plant is capable of covering a very large area of ground, and the deep driven stems are exceedingly difficult to eradicate. Woodwax (*Genista tinctoria*) (Fig. 19) possesses a very rugged woody underground stem, so full of "snarls" or kinks that the weed cannot be removed from pasture land by any means less heroic than ploughing up.

[1] These very thick stems do not appear in the specimen illustrated.

Sorrel (*Rumex acetosa*) (Fig. 20) is also provided with a much thickened stem, which, however, grows rather slowly and sends up aerial shoots at frequent intervals, giving the whole plant a clustered appearance.

(*β*) *Swollen Stems.*—In some plants the part of the stem below ground is swollen into a kind of tuber which is reproduced by means of small replicas of itself formed at the base. This is well shown by bulbous buttercup (*Ranunculus bulbosus*) (Fig. 21), and a very similar type is found in pignut (*Conopodium denudatum*).

(*γ*) *By Bulbs and Corms.*—These are in reality swollen underground stems which are clothed with scale leaves, instead of being merely the swollen bases of the aerial stems as in *β*. In *bulbs* the stem portion is at the base and is much flattened, giving off roots below, and bearing on its upper side a number of more or less fleshy scale leaves arranged one within the other. The flowering shoot is in the middle, and grows up above the soil, but the colourless scale leaves remain below ground. The only well-known farm weeds that have bulbs are wild onion (*Allium vineale*) (Fig. 34), ramsons (*Allium ursinum*) (Fig. 35), and spiked star of Bethlehem (*Ornithogalum pyrenaicum*). New bulbs are developed year by year between the scale leaves, arising from the stem portion, and as several may be formed from one bulb the spread of the weed is rapid.

In *corms* the stem portion is very solid and occupies most of the space. It is covered with a few thin chaffy scale leaves, quite different from the fleshy scales of the bulb. The general history of development is rather similar, new corms being formed either on top or by the side of the old one, the latter in this case perishing at the end of the year. The autumn crocus (*Colchicum autumnale*) (Fig. 32) is probably the only common farm weed characterised by this method of reproduction.

(*b*) *By Stems Running along the Surface of the Ground.*—In such weeds as bent grass (*Agrostis stolonifera*), silverweed (*Potentilla anserina*) (Fig. 41), mouse-ear hawkweed (*Hieracium pilosella*) (Fig. 22), creeping cinquefoil (*Potentilla reptans*), and creeping buttercup (*Ranunculus repens*) (Fig. 23), long thin stems are thrown out from the parent plants. These run along the surface of the ground, and at intervals develop a tuft of leaves and a number of rootlets. The latter establish themselves in the soil, and when once they have taken hold the young plants are capable of leading an independent

existence. Sooner or later the connecting stems may perish, but they often persist for a long period, so that a single plant may cover a considerable area of ground as the same process of reproduction goes on repeatedly. The conditions of the habitat largely determine the spread of these weeds. Under some circumstances the runners remain short, and the daughter plants are grouped closely round the parent, but in others the runners are lengthy and carry the plantlets well away, thus increasing the area of spread of the weed.

(*c*) *By Other Types of Vegetative Reproduction.*—Some weeds have developed very specialised types of reproduction

FIG. 22.—MOUSE-EAR HAWKWEED (*Hieracium pilosella*).
A. Runners (above ground).

which, though less common than the two preceding classes, are quite effective in aiding the distribution of the species.

The reproduction of the wild onion (*Allium vineale*) by means of seeds and underground bulbs has been described, but it has still a third method, as the flowering heads always carry a number of small bulbils at the base of the flower stalks. It often happens, indeed, that the flowers are entirely absent, so that the "flower head" consists of a main stalk bearing aloft a cluster of small bulbs. These ripen and fall to the ground, where they start into growth and give rise to new onion plants. It is largely because of this triple method of reproduction that the wild onion is so difficult to exterminate.

Onion or knotty couch (*Arrhenatherum avenaceum, var.*

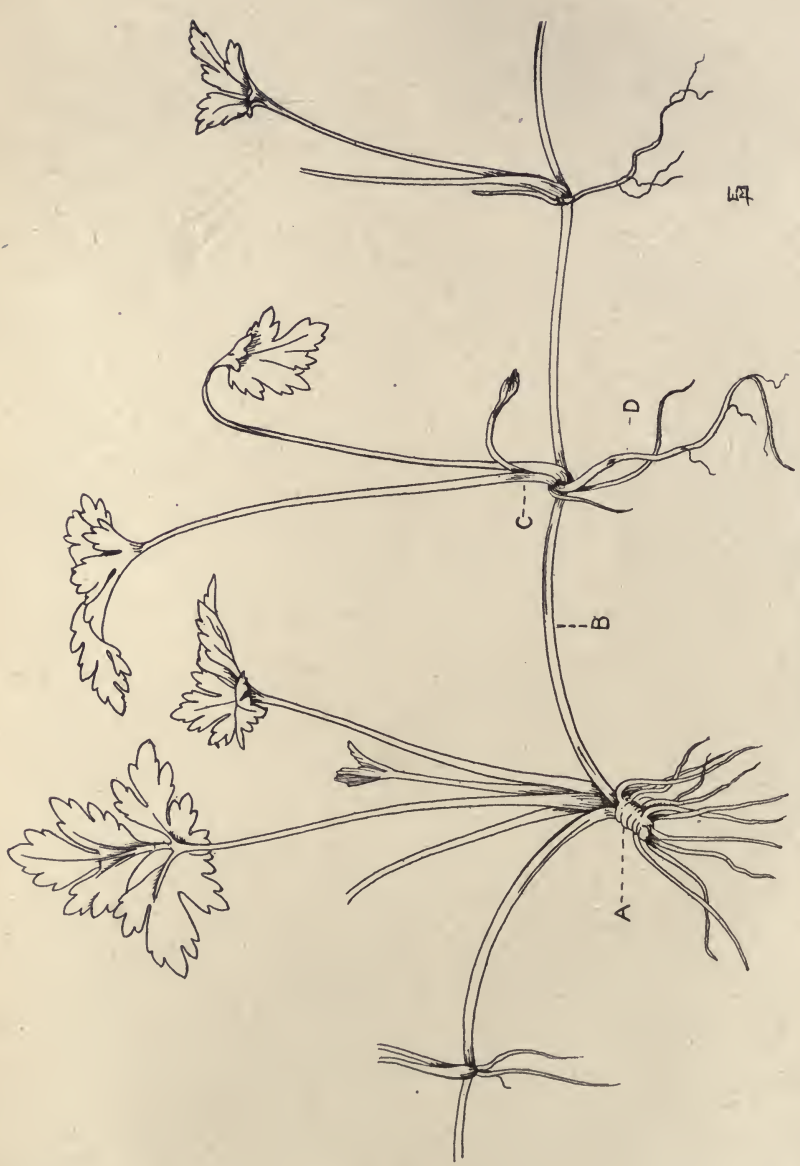


FIG. 23.—CREEPING BUTTERCUP (*Ranunculus repens*).

A. Original or Mother Plant. B. Runner (above ground). C. Daughter Plant. D. Roots.

FIG. 24.—ONION COUCH (*Arrhenatherum avenaceum, var. tuberosum*).
A. Swollen Internodes. B. Leaves from Nodes between Swellings.

tuberosum) (Fig. 24) is a variety of tall oat in which the stem becomes greatly swollen between the leaves, giving rise to a string of "knots" with leaves springing from between them. These "knots" are very tenacious of life, and each is capable of developing into an independent plant. It has been suggested that this habit of growth is only induced by special conditions of environment, but experiments by L. M. Underwood[1] at Rothamsted indicate that the plant is a genuine variety, breeding true to type under whatever conditions it is grown (see p. 90).

Most of the farm weeds that are at all conspicuous are described above, but in many others the method of distribution is not sufficiently striking to merit inclusion with the outstanding types. Most of these plants are dependent upon seeds for their reproduction, though some spread by their vegetative parts, but the quantity of seed produced and the efficiency of the vegetative reproduction is not sufficient to bring the weeds into prominent notice except under very special circumstances, when from one cause or another a comparatively insignificant weed becomes abundant and demands attention.

[1] Underwood, L. M. (1912), "A Note on Onion Couch," *Journ. Ag. Sci.*, IV, pp. 270-272.

CHAPTER III.

PREVENTION AND ERADICATION OF WEEDS.

Prevention.

THE harm and loss caused by weeds is so fully recognised that in many parts of the world legislation is in force to control the occurrence and spread of weeds, the laws being both preventive and remedial in nature. In many cases it is an offence to deal in agricultural seeds which contain more than a certain minimum percentage of specified weed seeds, and, very frequently, certain weeds are regarded as noxious and must be either eradicated or well kept under, in default of which severe penalties are enforced. The Dominions and several European countries are very active in this respect, but up to the present little action has been taken in the British Isles, though a certain amount of control is exercised in Ireland and the Isle of Man.

In those countries in which effective action is taken the power of control conferred by legislation is very elastic. Weeds definitely proclaimed as noxious have to be kept down and in addition local authorities may proclaim other weeds as circumstances arise. In the case of defaulters, the authorities are given power to have the work carried out and to claim the cost from the landowner or occupier, as is done in the Transvaal, Canada, Australia, and elsewhere. Further regulations ensure that the seed imported from abroad shall be free from weed seeds. This is most essential, as in parts of Australia the weed flora among the arable crops on cleared land consists almost entirely of alien weeds imported with the crop seeds, while the native vegetation has entirely died out. In Canada, too, many of the worst weeds have arrived from Europe in the same way. So far no regulations as to weed control are existent in this country, and farmers have full liberty to present their neighbours with unlimited supplies of the seeds of thistles, docks, and other evil

weeds. In this way a good farmer may be seriously handicapped if he has a careless neighbour, and much money is spent annually for labour in weeding that might be saved if some measure of legislative control were introduced. However, the Testing of Seeds Order, 1917,[1] may have an indirect beneficial action by encouraging farmers to harvest their crops as free from weed seeds as possible.

Weeds are ubiquitous. The soil is full of seeds awaiting opportunity to germinate; weed seeds lurk in hedges, trees, farm implements, and in all sorts of nooks and crannies; wind carries others from long distances; water and animals all play their part in distribution. It is thus obvious that it is impossible to keep any farm entirely free from weeds, but nevertheless a great deal may be done by way of prevention. The chief preventive measures that are practicable on any farm are:—

(1) To sow clean seed, free from weed seeds.

(2) To prevent any weeds from forming seed and so reproducing themselves in that way.

(3) To clean farm machinery, especially if borrowed, to prevent weed seeds being carried from place to place.

(4) To avoid throwing rubbish from ricks, barns, and other sources on to arable land.

(1) The official Seed Testing Station is prepared to examine any sample of agricultural seeds that may be submitted and to report on the nature and quantity of the injurious weed seeds that may be included, in addition to reporting the percentage germination and purity of the crop seed itself. The Testing of Seeds Order requires that these particulars shall be furnished by the vendor to the buyer before the transaction is completed, so that the onus rests on the purchaser if he is foolish enough to buy seed containing a total of more than 1 per cent. of such injurious weed seeds as docks (*Rumex conglomeratus*, Murr; *R. obtusifolius*, L.; *R. crispus*, L.), sheep's sorrel (*R. acetosella*, L.), wild carrot (*Daucus carota*, L.), Yorkshire fog (*Holcus lanatus*, L.), soft brome grass (*Bromus mollis*, L. *et spp.*), suckling clovers (*Trifolium dubium*, Sibth; *T. procumbens*, L.; *T. parviflorum*, Ebrh, and *T. angulatum*, Waldst).

(2) In order to prevent weeds from forming seed, methods of cultivation suitable to the particular circumstances should be put into operation. All these are identical with those described for eradication in the following section, but they

[1] Testing of Seeds Order (1917), *Jour. Bd. Agric.*, XXIV, pp. 1031-1039.

must be applied early enough in the life of the weeds to prevent any danger of seed formation even in the most forward specimens. So much seed is produced by individual plants of docks, thistles, poppies, and others that if even half a dozen plants are allowed to ripen they can supply sufficient seed to restock a large area the following year.

(3) Large numbers of weed seeds are carried about the country by agricultural implements, and now that machinery of larger type, that passes from farm to farm, is coming into common use the danger of contamination from this source is increasing. Steam ploughs and cultivators, motor ploughs, and other types of machinery tend to carry about clods of soil in which numerous weed seeds are buried. Threshing machines, binders, wagons, and other appliances for dealing with the harvested crops become thoroughly infested with large numbers of weed seeds and these are carried from place to place unless the utmost care is taken to keep the machines scrupulously cleaned out after use.

(4) Large collections of weed seeds occur at the bottom of corn and hay ricks, in barns and similar places. All such rubbish should be burned if possible, or, if suitable for feeding animals, may be steamed or thoroughly ground up in a mill in order to crush the weed seeds beyond possibility of germination. This, however, is hardly feasible, as it is not worth the cost. Too often this source of infection is overlooked, even on farms that are otherwise well protected against the ingress of weed seeds, and much damage is thereby caused.

Eradication.

The most effective measures of weed prevention are bound to fail unless a constant system of eradication is in force. From one year's end to another it is possible and necessary for the farmer to be combating the weeds, so that he always remains master and never lets them get the upper hand. The methods of eradication are many, but most of them can be summed up under the heads of eradication by mechanical and by chemical means. A few special methods are occasionally used which cannot quite be classified in this way, but these are the exception rather than the rule.

From the very early days of agriculture cultivation has been regarded as the principal means of getting rid of weeds. The old husbandman knew nothing of our modern agricultural machinery and carried on his work with the old-fashioned

implements worked by hand and animal labour. No chemical substances were recognised in agriculture, and naturally enough the methods employed were conservative and farmers did not foresee future improvements. In this way one finds Blith[1] stating that ploughing is the only cure for weeds, and that such common weeds as nettles, docks, chickweeds, and hemlocks (chevils ?) are caused as much by over-rich and fat soil as by anything else. Our knowledge has advanced since those days, the true cause of the prevalence of weeds is better understood, and many kinds of mechanical and chemical methods have been devised to deal with them.

The system under which land is farmed has much to do with the particular methods adopted for the eradication of weeds. Methods that are possible and effective on ploughed land are impossible of application on grass-land, besides which the types of weeds that occur under the two systems are quite different. It will therefore be necessary to make a sharp distinction and to consider separately the methods of exterminating weeds on arable and grass-land.

I. *Eradication of Weeds from Arable Land.*

(*a*) *Eradication by Methods of Cultivation—Mechanical Means.*—The primary method of removing weeds from arable land is ploughing, for unless some clearance is first effected in this way whatever other methods of cultivation may be carried out are of little avail. In ploughing the surface vegetation is bodily reversed and buried under a mass of soil which prevents the leaves of the plants having access to the light and air essential to them. The roots are cut off from communication with the lower soil, and in this position the plants are subjected to baking and consequent withering if the weather be hot, or if it be wet and cold the crowns are surrounded with so much dampness that they rot away. This effectively disposes of large numbers of the annual weeds that have fibrous roots, while the top growth of perennials is also destroyed.[2] The act of ploughing, however, breaks up the roots or the underground stems of the perennials, and unless further measures are taken much harm may result. If

[1] Blith, W. (1652), "Survey of Husbandry Surveyed".

[2] The Russians advocate very deep ploughing (12 inches at least) as by that means weed seeds are buried at such a depth that they cannot grow. See Anzibor, S. (1912), *Bull. Bur. Agric. Intelligence and Plant Diseases*, III, pp. 2313-4.

these broken pieces are left in the soil after ploughing the field will shortly be covered with far more of the perennial weeds than were present in the first instance. An excellent instance of this was seen by the writer in the summer of 1918 on a neglected farm in Suffolk. The arable land had been getting into poor condition for some years, and in 1916 an attempt was made to work some of the fields with the steam plough. For some reason no after-cultivation of any kind was carried out, and in August, 1918, it was covered with a dense rank herbage consisting almost entirely of "water grass" (*Agrostis* or twitch), together with an army of curled docks that were seeding freely. The condition of the land thus treated was so hopeless that even the farmers of the neighbourhood, experienced in dealing with that particular type of soil, confessed themselves unable to tackle the problem of reducing the chaos to a semblance of order. This is a practical demonstration of the necessity of following the plough with other implements which will gather up the fragments of perennial weeds in order that they may be collected and destroyed. Repeated harrowing after ploughing serves the double purpose of collecting these weeds and of reducing the soil to the fine tilth most favourable to germination. This in itself is a valuable aid to weed eradication. The soil is full of weed seeds and the good tilth encourages them to germinate rapidly, and it is an easy matter to destroy the delicate seedlings by further cultivation, so disposing of some proportion of the stores of buried seeds. If it is not necessary to sow the crop immediately this process can be repeated, as each cultivation of the surface maintains a good seed bed for the germination of the weeds.

Even after the crops are sown and are well through the soil it is possible to destroy the weed seedlings by using the appropriate farm implements. Special machines have been invented to meet this need, and the Poppy Destroyer and the American Weeder[1] are but two of the various types employed. Among some crops it is possible to run the horse-hoe, but under special circumstances, where a particular weed is troublesome and labour is available, the surface cultivation is carried out with the hand-hoe. When the crops become too high to admit of the passage of any cultivator it is necessary to resort to hand pulling for the removal of the larger weeds, and if necessary the hand-hoe can be kept going for some time longer. Large individual weeds, as thistles, that cannot

[1] Long, H. C. (1910), "Common Weeds of the Farm and Garden," pp. 34-35.

be pulled out easily should be constantly spudded in order to exhaust the underground parts as much as possible. Corn sowthistle (*Sonchus arvensis*) is one of the weeds that require constant attention. It should be cut early in the year soon after it comes above ground, and the cutting should be repeated as often as possible during the season.

After the weeds have been collected they should on no account be allowed to lie about on the ground, particularly if they are approaching the flowering stage. Such plants as docks and thistles have such large stores of food in their underground parts that if they are far enough advanced it is in many cases possible for them to continue growing even after they are pulled up from the soil, so that they can ripen and shed their seed. For this reason the accumulation of docks and thistles in heaps in the hedgerows should be discountenanced. All weeds and parts of weeds should be burned straightway or removed from the field and mixed with lime to rot them down into a compost. Even this latter proceeding is dangerous if seeding is at all advanced, as many seeds have such a hard covering that they fail to rot, and even though they are buried in the lime they are likely to remain uninjured in the compost heap ready to spring into activity when the manure is spread on the land and favourable conditions arise for germination.

When a heap of manure is kept for any length of time and reaches a fairly high temperature in the interior it is probable that many weed seeds perish from the heat developed. Some species seem proof against almost any adverse circumstances, and very frequently the first plant to spring up where a heap of stable manure has stood is knotgrass (*Polygonum aviculare*), while fat hen (*Chenopodium album*) grows so freely upon a manure heap that it is often called mixen-weed or muck-weed.

As it is all-important to prevent seeding any practicable method should be adopted to avoid it. In some cases wild radish is troublesome and is too abundant to be pulled out by hand. It has been suggested[1] that when it occurs among corn crops the plants should be "topped" with a scythe at the time of flowering so that seed formation is impossible.

It is sometimes advisable to reverse the order of working and to begin to effect a clearance before ploughing is done. This is specially useful after dirty crops like peas, which leave a stubble full of such pests as couch-grass and twitch. A

[1] *Jour. Bd. Agric.* (1908), XIV, p. 696.

heavy harrow run over the stubble will drag up much of the weed, and if the latter be collected into heaps and burnt there and then on the ground, the ashes help to fertilise the soil and the land is more fit for ploughing. This may be done even on heavy land when "running grasses" are a nuisance. On light, sandy land this is the recognised method of dealing with twitch, as at every available opportunity the cultivator is run over the soil to gather the stuff up ready for burning.

It is occasionally possible to take advantage of the preference of weeds for certain soils in order to eradicate them or to prevent them from being spread from place to place. Sheep's sorrel (*Rumex acetosella*) requires soil of a very open and light nature, and anything that consolidates the soil tends to suppress the weed. Anderson (1779)[1] quotes an instance of an experiment in which sheep's sorrel was eradicated by thoroughly rolling the land. Many weed seeds are carried about in farmyard manure, and as the weeds that are most abundant on heavy land differ from those that prefer light soil, Hardie (1904)[2] suggested that wherever possible the manure made from straw grown on heavy land should be put on to light land, and vice versa, and then the weed seeds would have less encouragement to flourish in their new environment.

The methods above described are those that are applicable to arable land irrespective of the crops carried. The crop itself, however, can be used as a valuable instrument in weed eradication, whether on account of its habit or the particular type of cultivation it requires. Roots are most valuable cleaning crops, and are often sown when a piece of land has grown so foul that it needs special treatment. Most root crops, as mangels, swedes, and turnips, are sown so late in the season that a long time is available in the spring for cultivating and clearing the land of weeds as described above. Then, when once the crop is up, it needs constant attention and cultivating from first to last. The horse-hoe is used to clear the spaces between the rows, later on hand-hoeing takes place to single the plants, and to the very end it is necessary to keep the land well worked if a good crop is to be obtained. All this cultivation and working of the soil is the very thing to clear the weeds out of the way. The weed seeds find a perfect seed bed in which they germinate, only to be cut down

[1] Anderson, J. (1779), "Essays on Agriculture," Vol. II, pp. 215-226.
[2] Hardie, W. (1904), "Destruction of Weeds by Surface Cultivation," *Jour. Bd. Agric.*, XI, pp. 193-201.

at the next stage in cultivation. Fresh seedlings arise to meet with the same fate, and very few plants are able to reach maturity to replenish the store of seed in the soil. Two root crops in succession will make a wonderful clearance even on badly infested land, and this method has been successfully used in getting rid of shepherd's needle (*Scandix pecten*), which is troublesome in some places.[1]

A totally different method is adopted when "smother crops" are grown. In this case the weed and crop seeds start into growth together, but before long the crop grows ahead much more rapidly than the weeds, and as the latter are deprived of light by the overshadowing of their competitors they are killed out before they attain any size. Clover, lucerne, sainfoin, and mustard are among the more common smother crops. Lucerne is particularly effective, because it is cut so often during the season that all the weeds that grow are cut off before they seed, and as the crop occupies the ground for several years a good clearance is effected. Couch-grass (*Agropyron repens*) has been effectively dealt with in this way. In a French test[2] vetches were sown on a field infested with couch-grass in April, 1910, and a good hay crop was taken in July. By this time the vetches had "gone down" and smothered all the top growth of weeds, so that after mowing the field was clean and fit for sowing lucerne the following spring. Three good cuts of lucerne were obtained in 1911, as the couch had no opportunity of asserting itself and spoiling the crop.

When crops are grown for silage very good opportunities arise for clearing the land of weeds, provided the ground is broken up directly the crop is removed, so that the weeds are foiled in any attempt to reassert themselves.[3] The silage crop exhausts the soil moisture very considerably, and if the ground is ploughed without delay the weeds rapidly dry up, particularly if the process is favoured by hot, dry, summer weather. It is usually possible to carry out this work because it comes between hay and corn harvest, when more time is available. The perennial weeds are not exterminated by such silage crops as oats and tares, but they are suppressed for a time and so weakened that they are more easily dealt with in other ways.

[1] Long, H. C. (1912), "Identification and Eradication of Some Common Weeds, IV," *Jour. Bd. Agric.*, XIX, pp. 273-277.

[2] *La Terre Vaudoise* (1911), No. 50, p. 458.

[3] Amos, A. (1917), "Some Problems in the Growth of Silage Crops," *Jour. Bd. Agric.*, XXIV, pp. 167-168.

Some weeds, however, seem to be proof against all methods of eradication, especially if they occur on soil to which they are particularly suited and where they normally grow in great abundance. Corn marigold (*Chrysanthemum segetum*) tends to resist all attempts to remove it. In one case,[1] when it had so completely destroyed two acres of barley that harvesting was not attempted, the land was sown down to green crops for four successive years with no success. This weed has long had an unenviable reputation, for even in 1727 Threkeld wrote, " Maunour courts do amerce careless tenants who do not weed it out before it comes to seed ". Some success may be obtained by growing several successive root crops on infested land, provided scrupulous care is taken with the hoeing so as to allow no plant to seed. Older writers claim that manuring with chalk is effective.[2] This weed is very troublesome in turnip fields on the sandy soil of Norfolk.

Wild oats is a bad weed in some districts and is difficult to get rid of. Adam [3] (1789) claimed that it could be eradicated by putting infested land down to clover and mowing the oats and clover together before the oats were ripe. The plant is annual, so the roots do not shoot out again, and flowering would thus be prevented. It seems doubtful whether one year only of this treatment would be really effective. Observations made by the writer in Suffolk seem to show that wild oat seed is capable of lying dormant for some years, and a stock of ungerminated seed would probably remain ready to spring up after the removal of the clover crop. Deep ploughing of land infested with wild oat serves to bring up a large stock of dormant seeds into conditions favourable for germination. Some of these germinate at once and are cleared away if thorough surface cultivation is carried out. Most of the seeds, however, bide their time and germinate among succeeding cereal crops, so that the deep ploughing really encourages an increase in the crop of wild oats in future years; in France it was considered that the deep ploughing carried out in 1912 favoured the invasion of this pestilent weed in 1913.[4]

When a smother crop is grown it is of course necessary

[1] *Jour. Bd. Agric.* (1907), XIV, pp. 536-537.
[2] " Gleanings from Agriculture " (1802).
[3] Adam, J. (1789), " Practical Essays on Agriculture," II, pp. 173-198.
[4] Rabaté, E., " La Folle Avoine " (1913), *Le Progrès Agricole e Viticole*, 33, No. 32, pp. 116-180.

that the crop seed should be free from weed seed. This can now be easily assured by the guarantee that must be issued with all seeds sold, but hitherto much care has been necessary. Cleavers (*Galium aparine*) was a common impurity in rape seed, and in the districts bordering the North Sea it was usual to clean the rape by running the seed over a cloth, when the rape rolled off while the cleavers seeds were caught by the cloth by means of their hooks.[1]

When all other methods fail two more drastic treatments may be tried: the land may either be fallowed for a season or, as a last resort, it may be laid down to grass for a term of years.

Under the old system of agriculture fallowing was usually regarded as an integral part of the rotation of crops, but with improved methods of cultivation and the increased use of manures it is now less generally used unless for such a specific purpose as clearing land of specially bad weeds. If land can be kept clean without a bare fallow it is usually more profitable to keep it cropped continuously, partly because the value of the extra crop is obtained and partly because a definite loss of nitrogen has been proved to occur when soil is left bare and exposed without any green covering. Under some circumstances, however, and especially on heavy land, a bare fallow proves the most effective and prompt means of reducing the weeds. For this purpose the land should be ploughed and harrowed to remove as many weeds as possible, and then be cultivated to provide a tilth in which the weed seeds in the soil may be encouraged to germinate. Further ploughings and cultivations must be carried out during the season, the great object being to obtain as many weed seedlings as possible in order that they may be destroyed forthwith. It is essential that the intervals between the cultivations should not be long enough to allow any of the weeds to seed, and careful watch must be kept, as some weed species flower and seed with great rapidity under all circumstances and, if the season be dry, the longer lived weeds may be induced to hurry on their seeding processes on account of the drought. Fallowing may be particularly effective when for any reason a succession of straw crops has been carried on the same field. The Broadbalk field at Rothamsted, which has carried wheat for seventy-five years, since 1843, is badly infested with black bent (*Alopecurus agrestis*), so badly that constant hoeing and hand pulling fail

[1] *Jour. Bd. Agric.* (1912), XIX, p. 321.

to keep it in check. Consequently half of the field was fallowed in 1914 for a season and the other half in 1915, and the following years far less of the pest was in evidence.

When all other means of eradication fail, whether they be methods of cultivation or "chemical" means, obstinate weeds will sometimes disappear if the land be laid down to grass for a term of years. This was fully recognised in the eighteenth century, and is still practised when necessary at the present day.

Anderson [1] (1779) noticed that couch-grass and knotgrass only occur while the land is under cultivation, or at most for a year or two after it is laid down to grass, "after which they usually disappear and are no longer seen till the land has been again in tillage for some time. And it is in this way alone that the farmers, in some of the worst cultivated parts of Scotland, know how to get rid of these destructive weeds."

Adam [2] (1789) claimed that to extirpate coltsfoot (*Tussilago farfara*) thoroughly the land must be long laid down to grass, though he admitted that it was once almost destroyed by two successive crops of vetches, and that it may be killed by allowing the land to lie for a sufficient time under clover and ryegrass.

Most excellent results have been obtained by an adaptation of this method in recent years in dealing with wild onion (*Allium vineale*). This is only troublesome on heavy soil, but is sometimes so abundant as to ruin the crops, and no ordinary method is effective in reducing it. The plant spreads in three ways, by means of seeds, by bulbils formed in the flowering head, and by "offsets" from the subterranean bulb. Experiments were carried out at the Woburn Experimental Station [3] and also on fields at Woburn and Chelsing in which the pest was very abundant. Many chemical treatments were tried, with little or no success in most cases, and various mechanical treatments, such as cutting off the flowering heads, pulling up plants by hand, deep-ploughing the land, and burning the soil, were equally unsuccessful. Experiments in which the soil was lightened by mechanical addition were more promising, indicating that if the land could be opened up and more effective drainage provided the weed might eventually be got under. It was therefore decided to sow plots down with "Elliott's mixture," a mixture of grass

[1] Anderson, J. (1779) (3rd edition), "Essays on Agriculture," II, p. 38.

[2] Adam, J. (1789), "Practical Essays on Agriculture—On Weeds," pp. 173-198.

[3] Voelcker, J. A. (1911), "Eradication of Wild Onion," *Jour. Roy. Ag. Soc.*, 72, pp. 404-409.

seeds with some deep-rooted plants such as chicory, burnet and kidney vetch, since the latter send down large, strong roots which open and aerate the land. Great success rewarded the attempt. At the end of six years the plots of grass from Elliott's mixture were ploughed up, and after the most careful search hardly a single onion was to be found, while the adjacent plots were so smothered with bulbs and green tops that they gave the land a distinctly white appearance. Further experiments were made on the infested area to compare the effect of a cheaper grass mixture, containing only Italian ryegrass and red clover, with that of the more expensive "Elliott's mixture". When the land was ploughed up in 1916[1] it was found that the cheaper mixture, in which deep-rooted plants were absent, had been far less effective in eradicating the wild onion, while the Elliott's mixture had brought about a complete clearance.

When land is laid down to grass for the purpose of weed eradication it is necessary to keep the pasture down for a sufficient number of years in order that the underground parts of the perennial weeds may have time and opportunity to rot away. Such a clearance is not effected in a year or so, but if it is to be thorough takes some considerable time. Meanwhile the land will be producing hay crops and so will not be running at a loss.

(*b*) *Eradication by Spraying and Manuring.—Chemical Means.*—During the past few years many attempts have been made to combat weeds by various chemical means, the great object being to find some application which will destroy the weeds without injuring the crop. A considerable measure of success has attended the experiments, but the natural conservatism of farmers has up to the present prevented the new methods from being widely adopted, though some headway is being made.

The great factor that makes for success in this chemical treatment lies in the difference between the habit of most weeds and that of such crops as cereals. The long, narrow upstanding leaves of cereals, which are often covered with "bloom," tend to throw off rapidly any moisture that falls upon them, with the result that even if they are treated with a poisonous or corrosive substance injury does not necessarily follow. The majority of weeds, however, have broad leaves

[1] Voelcker, J. A., "Occasional Notes" (February, 1918), *Roy. Ag. Soc.*, No. 4, pp. 1-3.

which stand out at an angle from the stem, retain moisture long enough to allow any poisonous agent to become effective. This is particularly the case if the leaves are rough or crinkled, as the irregularities hold the moisture for a longer time. It is more difficult, and often impossible, to apply chemical methods for the eradication of weeds among leguminous crops, as the broader leaves of clover, trefoil, sainfoin, serradella and others behave like the leaves of weeds, and hold the chemicals long enough to cause serious injury to the plant.

With root crops the constant cultivation carried on is usually sufficient to keep weeds in check, so that as a rule it is only cereals that are dealt with by chemical means.

The success of the chemical eradication of weeds is to some extent dependent upon the weather. It is essential that the substance employed should remain upon the leaves long enough to come into action, and, therefore, if heavy rain falls immediately after an application much of the benefit is lost. Consequently it is necessary to watch the weather carefully, and if unfortunately rain supervenes too soon, the application should be repeated. Again, if a dry substance is employed it would easily be blown away if applied when the leaves were dry, so in this case it is usual to carry out the work when the plants are wet with dew, as by that means the chemical is fastened to the leaves and does not tend to blow away when they dry.

The chemical substances used as weed killers can be divided into two groups:—

(1) Chemicals that merely destroy the weeds and have no direct beneficial action upon the growth of the crops. These substances are usually applied in the liquid form as *sprays*.

(2) Compounds that not only destroy the weeds but also exercise a manurial action, thus directly benefiting the crop at a later date. These substances are usually very finely ground *manures*, and are applied as dry powders when the leaves are damp.

(1) *Sprays*.—Most of these are corrosive in nature, and burn up the delicate tissues of the leaves and stems, either killing the weeds outright or so crippling them that the crop is able to get well ahead before the weeds can again start into growth to any extent. These chemicals are always applied in solutions of various strengths. Copper sulphate, iron sulphate and sulphuric acid are the most general sprays, but various other soluble substances have been tested.

Copper Sulphate.—This is probably the most familiar of all weed sprays, and has been experimented with for years. It is most generally associated with the destruction of charlock (*Brassica sinapis*), but its use has been extended to other weeds. The rough crinkled leaf of charlock makes it a most favourable subject for eradication by spraying, and, given suitable weather, the treatment rarely fails to make a considerable reduction. It is usually best to spray when the weeds are small, with three or four well-developed leaves, but under favourable conditions success will often attend much later spraying. On a farm in Gedling, Notts, a few years ago charlock was successfully sprayed when in full flower, but this practice is not one to be recommended. On the same farm it was noticed that while most of the charlock succumbed a number of plants remained uninjured: closer investigation showed that the latter were a different species, *Brassica campestris*, which has smooth, rather waxy leaves, off which the spray rolled without exercising its corrosive action. Various experiments indicate that the best strength to use is 4 or 5 per cent. (4 or 5 lb. copper sulphate in 10 gallons of water), applied at the rate of about 40 gallons per acre. In some cases a 3 per cent. solution is effective, but only under specially favourable conditions.[1]

A 5 per cent. solution of copper sulphate at the rate of 50 gallons per acre is useful for eradicating spurry and does its work thoroughly, but a weaker strength, 3 per cent., is only partially effective and allows about half the weed crop to form and ripen its seeds.[2] [3] In the latter case the spurry is injured and checked at first, as the shoots shrivel and become brown at the tips, but later on many plants recover considerably. This recovery is prevented by the use of the 5 per cent. solution. Poppies are sensitive to this spray, and even a 2 per cent. solution does them harm. It has been suggested that two applications of a 3 per cent. solution, with an interval of a few days, might prove quite effective in eradicating them.[4]

In some cases the action of the corrosive spray is strength-

[1] "Charlock Destruction" (1909), *Bull.* I, *Agric. Dept., Univ. Coll., N. Wales, Bangor.*

[2] "Spraying of Charlock and Spurry" (1908), *Bull.* II, *Agric. Dept., Univ. Coll., N. Wales, Bangor.*

[3] "Destruction of Spurry in Corn" (1906), *Bull.* IX, *Agric. Dept., Univ. Coll., N. Wales, Bangor.*

[4] "A Common Weed—The Poppy" (1909), *Jour. Bd. Agric.* XVI, pp. 26-31.

ened by the addition of a soluble manure, which acts as a stimulant and enables the crop to get ahead of the weeds before any that may survive have time to recover. Corn buttercup (*Ranunculus arvensis*), if very strong, is only burnt and not destroyed by a fairly strong solution of copper sulphate, 4½ per cent. In one experiment[1] the amount of chemical was more than doubled, to 9·9 per cent., and 22 lb. of sodium nitrate was added to the 10 gallons of water. About 35 to 40 per cent. of the weeds were killed or injured, and before the rest could make much growth the wheat had benefited so much by the nitrate that it pulled right ahead of the weeds. Such strong applications of copper sulphate, however, need very careful handling, and are not to be advised under ordinary circumstances.

Iron Sulphate.—In most cases this can be used as a substitute for copper sulphate, and very often the iron compound is the more effective of the two, provided that suitable strengths are employed, as stronger concentrations of the iron salt are necessary. It has been largely used abroad to eradicate charlock, and experiments have also been carried out in this country. Quite good results have been obtained with 40 gallons of 7 per cent. solution per acre, particularly on oat crops. It was found that copper sulphate caused the young oats to flag more than the iron sulphate, but, on the contrary, young barley received more initial check from the latter spray. Hiltner[2] used a far more concentrated solution in larger quantities, applying 53 gallons per acre of a 22 per cent. solution to infested oats. Excellent results were obtained, and the yield of oats from a plot treated thus was six times that from an untreated plot. Care was taken that the plants were completely dry before the spraying was done, and the drastic effects on the charlock were visible within two days. The German Agricultural Society[3] recommend the addition of 5· per cent. of molasses to cause the solution to adhere to the weeds more firmly. Iron sulphate may also be applied dry as a fine powder,[4] at the rate of 3 to 4 cwt. per acre. It

[1] Martin, J. B. (1916), *C.R. de l'Academie d'Agriculture de France*, II, pp. 420-424.

[2] Hiltner (1911), *Praktische Blätter für Pflanzenbau und Pflanzenschutz*, Jan., Feb., Summ. in *Jour. Bd. Agric.*, XVIII, pp. 41-42.

[3] *Mitt. der deut. Landw. Gesell.* (1911), *Flugblatt*, No. 11, Summ. in *Jour. Bd. Agric.*, XVIII, p. 244.

[4] *Bull. Soc. Nat. d'Agric.* (1909), No. 5, Summ. in *Jour. Bd. Agric.*, XVI, p. 761.

may be broadcasted or scattered by machine early in the morning while the leaves are still wet with dew.

All cereal crops, and also the leguminous crops sown among them, will resist dusting or spraying with iron sulphate. The leguminous plants owe their immunity, in this case, to the fact that they are to a great extent protected by the larger growing weeds and the cereals, so that comparatively little of the spray reaches their leaves. Serradella, however, growing by itself, will not stand spraying with any dilution of iron sulphate or at any stage of growth, so that it has proved impossible to use this means of eradicating wild radish among this crop. Nearly all unprotected broad-leaved crops growing alone suffer badly, and beans, vetches, yellow and white lupins, roots and potatoes are much injured by the iron sulphate, though peas and blue lupins are rather less sensitive.

The iron spray is more effective than the copper salt in dealing with poppies and corn buttercups, a 15 per cent. solution reducing the weeds drastically. For the buttercup the spray is best applied at the beginning of February, and a 15 per cent. solution may be used as this is known to do no permanent harm to the cereal crops.

Sulphuric Acid.—This is the most corrosive agent that is used in the eradication of weeds. It attacks metals violently, including copper; therefore it is necessary to use special spraying machines and to wash them out thoroughly immediately after use to prevent them from being eaten away. Italian experiments indicate that if spraying is done at the right time the production of the cereal crop is not affected. For wheat it should be used during February and early March, when the plants have five or six leaves, at the rate of about 90 to 100 gallons per acre of an 8 or 10 per cent. solution made up with water. This method has been used in France, in Lot-e-Garonne, for destroying wild radish.[1] Sulphuric acid does not act as a universal weed destroyer, as all the weed grasses, including wild oat (*Avena fatua*), resist its action because their habit resembles that of the cereals. Medicks (*Medicago spp.*) and members of the lily family (as wild onion) also escape. The acid is deadly to most annual and biennial weeds, such as poppy, charlock, corn buttercup, cornflower, wild carrot, wild radish, vetches and vetchlings, and it clears badly infested

[1] Rabaté, E. (1911), "Destruction des Ravenelles par l'acide sulfurique," *Jour. d'Agriculture pratique*, No. 13, pp. 407-409.

fields of these pests very effectively.[1] For oats it is advisable to use about 60 to 70 gallons of the 10 per cent. solution per acre, and rather less for barley.[2]

Arsenite of Soda.—The very poisonous nature of this substance has prevented it from coming into general use for spraying purposes, and as it also has certain effects upon the soil it needs handling with much judgment. It is widely used in rubber plantations in Hawaii and among sugar canes in Australia, and in the latter case it is claimed that its use has reduced the cost of weed destruction by 25 per cent.[3] Arsenite of soda, like most caustic sprays, cannot be used on the broad-leaved crops without injuring them. In one attempt to rid alfalfa of dodder by this means the alfalfa was killed as well as the dodder. Besides this, there is danger of poisoning stock if a fodder or hay plant is sprayed with too much of it. The spray considerably alters the mechanical condition of the soil, acting as a deflocculating agent. It is strongly fixed by the soil and is not washed out even by very heavy rains, and consequently it is liable to remain for an indefinite time in the top few inches.[4] For this reason it is unwise to use the sodium arsenite spray too freely, as it may accumulate in the surface soil in sufficient quantity to act as a poison to any crop that is planted. With due care, however, and with particular crops, there is no doubt that this spray is decidedly efficacious.

Various Sprays.—In view of the difficulty in obtaining some of the more usual chemical sprays, such as copper and iron sulphate, various experiments have been made with other promising substances. At Rothamsted charlock plants in various stages of growth were sprayed with 3 per cent. solutions of nickel sulphate and copper sulphate to contrast the effect of the two. With young plants the nickel spray was much slower in taking effect than the copper spray, but at the end of six days all the plants were dead and made no recovery. With 6 per cent. solution the action was rather more rapid. Later on some very large plants just coming into flower were sprayed in a similar way, but although a few days afterwards the

[1] Morettini, A. (1915), *Le Stazioni sperimentali agrarie italiane*, XLVIII, pp. 693-716.

[2] Jaguenaud, G. (1912), "Sur la destruction des mauvaises herbes dans les Céréales par l'acide sulfurque," *Le Progrès Agricole e Viticole*, 29, pp. 332-334.

[3] "Weed-killing by Machinery" (1916), *Queensland Agric. Jour.*, V, Part 2, p. 61.

[4] McGeorge, W. T. (1915), *Hawaii Agric. Expt. Station, Honolulu, Press Bull.*, No. 50.

leaves were badly burnt by both sprays, the plants as a whole were not wilting or dying off. Probably a stronger solution would have been more effective at this stage, but the results suggest that the nickel sulphate would prove to be an effective substitute for copper sulphate, though it might be necessary to use it in somewhat greater concentration to hasten its action.

Potassium chloride in a 20 to 30 per cent. solution has proved effective in destroying charlock, as the plants touched by the liquid are completely shrivelled up. When the substance can be obtained more cheaply than at present it might well be given a further trial, as the potash is a most valuable manure and would be beneficial in this way after the initial work of weed destruction was over. The potassium chloride has no bad effect on the cereals, and may be used at the rate of 352 lb. dissolved in 1092 gallons of water per acre.[1] Strictly speaking, this substance comes under the head of manures, but as for the purpose of weed destruction it is applied as a spray it is more conveniently dealt with here.

In some places sodium bisulphate can be readily obtained from the powder works at a cheap rate, and in parts of France farmers have been able to get it in truck loads of 5 or 10 tons at the rate of 9½d. per 220 lb. free on rail. It is a most effective weed killer, resembling sulphuric acid in its action, but it needs less precautions in its use. 80 gallons per acre of 45 per cent. solution (i.e. 360 lb. of bisulphate per acre) are recommended for use if the fields are badly infested with weeds.[2] The stuff is, however, difficult to handle, so that full advantage is not taken of its availability.

(2) *Manures.*—The method of eradicating weeds by applications of finely ground manure is not very widely used, as few substances are yet known to be effective, but in recent years a good deal of work has been done in this direction with calcium cyanamide (lime nitrogen) and kainit.

Calcium Cyanamide.—Since the introduction of calcium cyanamide as a commercial manure the Germans have been using it to a considerable extent for destroying charlock and wild radish. Numerous experiments have demonstrated that it is quite efficient for this purpose, provided that it is applied when the plants are small and while the leaves are damp.

[1] Dusserre, C. (1916), *Travaux de Chimie alimentaire et d'Hygiene*, VII, pp. 357-358.

[2] *Feuille d'information du Ministère de l'Agriculture* (1918), XXIII, No. 8.

In German experiments the dressings used for charlock varied from 90 to 135 lb. per acre,[1] though in one experiment good results were obtained with only 60 lb. per acre.[2] In some cases the cereal crops were said to turn rather yellow for a few days after application, but they rapidly recovered, and, benefiting by the nitrogen in the manure, gave bigger crops than when no calcium cyanamide was used. Thistles were also very susceptible and were eradicated along with the charlock. On the other hand, in experiments carried on in North Wales,[3] calcium cyanamide, at the rate of 80 and 120 lb. per acre, had no permanent effect on charlock nor on the crop, and all the weeds recovered from the temporary check they received.

Good results are reported to have been obtained by treating wild radish with 1 cwt. calcium cyanamide per acre, but it is best to apply a heavier dressing if the weed is very abundant. In one case 150 lb. per acre, applied at the end of April, completely destroyed the radish, but the associated oat crop was eight days later in maturing on account of the heavy nitrogenous manuring. The yield of oats, however, was half as much again as that from the control plots that had been left untreated, the net profit from the use of calcium cyanamide being £2 15s. per acre.[4] Lime nitrogen is also effective against poppies.

Kainit—Kainit, at the rate of 4 to 8 cwt. per acre, is said to be quite useful in the suppression of charlock, and also in the eradication of many other weeds, frequently being more effective than either calcium cyanamide or iron sulphate. Heavier dressings are also recommended, from 10 to 16 cwt. per acre. The kainit needs to be very finely ground and should be sprinkled on the plants when they are wet with dew or rain, if possible on the morning of a fine day. For autumn sown cereals the best time of application is February or March, for spring sown corn the manure should be spread soon after the seeds have germinated. On very heavy land it may be necessary to apply a dressing of lime to prevent undue

[1] *Deutsch. Landw. Presse.* (4th Nov., 1908), Summ. in *Jour. Bd. Agric.*, XV, p. 776; (21st Jan., 1914), Summ. in *Jour. Bd. Agric.*, XXI, p. 64.

[2] *Mitt. der deutsch. Landw. Gesell.* (20th July, 1907), Summ. in *Jour. Bd. Agric.*, XIV, p. 568.

[3] "Charlock Destruction" (1909), *Bull.* I, *Agric. Dept., Univ. Coll., N. Wales, Bangor.*

[4] *Deutsch. Landw. Presse.* (24th Aug., 1912), Summ. in *Jour. Bd. Agric.*, XX, p. 618.

consolidation[1] of the soil. Cereal crops are very little harmed by the kainit and any damage is merely temporary, but peas, beans and other leguminous crops are more liable to suffer, as is usually the case when chemical weed killers are used. A comparison of the various tests made with kainit shows that it varies in its effect upon weeds, so that the latter may be classified according to their degree of susceptibility to the dressing.

(1) *Weeds most Susceptible to Kainit.*—Charlock, wild radish, black bindweed, speedwell, chickweed, nettle, groundsel, cornflower, mayweed (*Anthemis arvensis*).

(2) *Weeds Moderately Susceptible.*—Persecaria, spurry.

(3) *Weeds only Slightly Susceptible.*—Sowthistle, fumitory, poppy, spreading orache.

Various Manurial Dressings.—Attempts have been made to reduce weeds by attacking before germination the seeds lying in the soil. Any substance that is active enough to destroy weed seeds would be equally harmful to crop seeds, especially cereals, so if this method is adopted it must be tried at times when no crop seeds are lying in the soil, and when a sufficient period will elapse before sowing to permit the corrosive effect of the dressing to pass off. Cornflower seeds in the soil have been successfully destroyed by applications of carbolineum or chloride of lime, and numerous other weed seeds disappeared at the same time.[2]

Spurry is chiefly associated with light soils that are deficient in lime, and sheep's sorrel, though it is found on both light and heavy soil, also indicates lime deficiency. Liming has been tried to eradicate both these weeds, with indifferent success in the case of spurry, with rather more success with sheep's sorrel. As a matter of fact the shortage of lime is usually very marked when these weeds are abundant, and it would be necessary to apply an almost impossible dressing of lime so to alter the balance as to render the situation untenable for these weeds. A mere 1 or 2 tons of ground lime per acre has no effect on spurry, though doubtless it effects some degree of improvement in the soil itself. At Hodsock, an application of 10 cwt. salt per acre on very light sand in poor condition killed spurry in patches, but later on the weed took a fresh lease of life, and grew even more luxuriantly than on

[1] *Landw. Jahrb.* (1914), Bd. XLVI, pp. 627-657, Summ. in *Jour. Bd. Agric.*, XXI, p. 451.

[2] *Arb. Deutsch. Landw. Gesell.*; see *Jour. Bd. Agric.* (1914), XX, pp. 909-910.

an untreated plot, flowering and fruiting abundantly. Possibly a heavier dressing might have had more permanent effect.[1]

II. *Eradication of Weeds from Grass-land.*

On arable land certain periods constantly recur when the land is free from any crop, and even when a crop is growing there are spaces of bare soil between the plants which permit of cultivation. On grass-land all is different. The crop is always on the ground, and the plants are so closely associated that they are interlaced, and roots and shoots alike help to form a mat which completely covers the surface of the ground. For this reason weeds on grass-land can never be dealt with without taking the crop into full consideration, and the methods of eradication differ considerably from those adopted on arable land. They may, however, be subdivided into the same two main divisions of "mechanical" and "chemical" means.

(*a*) *Eradication by Methods of Cultivation—Mechanical Means.*—When grass-land is constantly grazed or constantly cut for hay the herbage takes on a special character according to the method of treatment, and certain weeds find congenial circumstances under each set of conditions. It is possible to take advantage of this in the eradication of the weeds, as by reversing the usual order and haying a grazed pasture, or grazing a mown field, the conditions are altered and the weeds do not flourish so well. Oxeye daisy (*Chrysanthemum leucanthemum*) grows very strongly in hay fields but resents interference in the early stages of growth. Close grazing with sheep in the early spring will materially reduce it, and for the same reason very early cutting of the hay crop is effective. This method can also be used to reduce false brome (*Brachypodium sylvaticum* and *B. pinnatum*) where it is plentiful, as on down pasture. Care is needed when animals are used as weed eradicators, as if the grazing is carried out on the wrong lines the weeds may be increased rather than diminished. A field known to the writer at Carhampton (Somerset) was infested with hardhead (*Centaurea nigra*). When the land was grazed exclusively by cows the hardheads waxed more and more strong, the cows apparently leaving them severely alone, but when sheep were run in as well an improvement was soon noticed, as the plants were grazed

[1] "Experiment to Check the Growth of Spurry," *Jour. Bd. Agric.* (1901), VIII, p. 54.

down closely and rapidly exhausted. On the other hand, grazing of common land by sheep alone may encourage bracken, because if broom is present the sheep eat the broom down closely and allow the bracken to flourish. Cattle, however, keep the bracken under and allow broom to hold its own. On dry calcareous pastures where the herbage is short and often weed-infested, geese are useful, as they graze very closely and appreciate the weeds. Generally speaking, mixed grazing is advisable where destruction of weeds is the aim, the preferences of cattle and sheep being quite different, and a more effective clearance is carried out when both agents are at work.

If hay fields are infested with large quantities of weeds that seed freely, such as yellow rattle (*Rhinanthus crista-galli*) early cutting of the hay crop is often useful as seeding is thereby prevented. It is, however, necessary to repeat this for two or three years in succession, for, though no fresh seeds may be produced, there are large stores in the ground which will come up in succeeding years and provide for the future if they are not cut down. Early cutting also keeps down rank weeds like wild chervil (*Anthriscus sylvestris*).

The most usual, and probably the most effective way of dealing with the chief weeds of grass-land, such as nettle, thistle, and bracken, is judicious cutting at appropriate times. All the worst pasture weeds have underground storehouses of food, either stems or roots, and if the weeds are to be eradicated it is necessary to cut when those storehouses are as empty as possible, so exhausting the plants. Thistles can be cleared by cutting three times in the season, beginning when the plants are well grown but have not come into flower. If they are cut in the first week in June and then twice in July for a couple of years hardly any thistles will remain by the third year.[1]

If three cuttings cannot be managed, a single cutting about the middle of June will do much good. Old agriculturists[2] recommend that thistles should be mown just before they blossom, leaving the stems about 4 inches high, and that then a large, heavy wooden roller should be run over the field so as to bruise the stalks thoroughly. The roller should be passed over four times one way and twice across.

[1] "Destruction of Thistles" (1908), (1909). *Reports of Field Experiments at Harper Adams Agric. College.*

[2] Hunter, A. (1803), "Georgical Essays," Vol. III, p. 203.

Yet again it has been suggested that the thistles should be cut an inch above ground, as water then gets into the stub and injures the crown of the plant, thus enfeebling the shoots, whereas if the plants are stubbed off below ground young and luxurious stools shoot up.[1] Nettles can be kept under by cutting regularly when the shoots are 6 to 12 inches high, and ragwort (*Senecio jacobæa*) can be eradicated by cutting just when it begins to show flower, provided it is not too strongly established. It sometimes happens that a weed, uncommon in most places, will become so abundant in a particular district as to be a real trouble. This is the case with the wood geranium (*Geranium sylvaticum*)[2] which is difficult to extirpate if it gets a hold. Some measure of success has been obtained by repeated cutting with the scythe, and it is possible that pasturing the field for several years might be useful, though cows do not seem to eat the plant.

Where it can possibly be done, bracken is readily dealt with by means of cutting, but usually it covers such large areas that this method is impracticable. The plants should not be interfered with too early in the year, one or two cuttings made when the bracken is well grown having been found to exhaust the underground food stores more thoroughly than if the young fronds are prevented from developing. Early July and August seem to be the best times in Wales and Scotland,[3] [4] but it might be needful to make the first cut rather earlier in warmer districts. It is necessary to repeat the process for two or more years, as cutting for one year only is of little use. Another way is to run chain harrows repeatedly over the ground at the time the fronds are coming up, for if this is done thoroughly and persistently the plants are greatly weakened.

Very low, close-growing weeds, like the stemless thistle (*Cirsium acaule*), are sometimes very troublesome on hilly pastures, as they cover a considerable amount of ground with their spreading leaves and kill out all other vegetation in that area. Their habit makes them difficult to eradicate, and repeated spudding, carried on throughout the summer, is

[1] "Gleanings from Agriculture" (1802), p. 409.

[2] Milburn, T. (1916), "Eradication of Crane's-bill from Meadows," *Jour. Bd. Agric.*, XXIII, pp. 688-689.

[3] "Eradication of Bracken," *Dept. Agric., Univ. Coll., N. Wales, Bull.* V (1914); *Bull.* III (1915).

[4] Gordon, G. P. (1916), "Bracken (*Pteris aquilina*) Life History and Eradication," *Trans. Highland and Agric. Soc., Scotland*, XXVIII, pp. 92-106.

practically the only effective remedy. Small patches may be cleared by covering them with strong sheets of tarred paper, which in the course of time by excluding the light destroys all vegetation underneath. Such patches must be re-seeded when eradication is complete.[1] The same method may be used for small patches of nettles.

Such weeds as rushes, willow-weed (*Polygonum persecaria*) and marsh horsetail (*Equisetum palustre*) only flourish where there is a plentiful supply of water held up by the soil, so that the land is waterlogged. Such conditions are harmful to most of the plants that are useful in herbage, and in order to improve the grass, as well as to eradicate the weeds, draining is the only effective remedy. Marsh thistle (*Cirsium palustre*) flourishes in damp fields and is also found on hilly pastures at any spot where a spring occurs, but it rarely causes much trouble.

In nearly every case, if careful attention be given to the matter, it is possible in the course of a few years to clear grass-land of weeds by the above methods without resorting to more drastic measures. Woodwax (*Genista tinctoria*), however, resists every attempt to eradicate it, and when once established in a favourable position it spreads rapidly and causes great depreciation in the value of the pasture. Stock refuse to touch it, either green or in hay, and apparently the only way woodwax can be eradicated is to plough up the whole field and keep it under arable cultivation until such time as the land is cleared of the underground parts of the pest.

On rich pasture land buttercups grow most abundantly and do not yield to ordinary methods of eradication. It has been found that a clearance can be made by ploughing up and carefully cleaning the land, and then taking at least one root crop off it, which enables still more cleaning to be done. If the land is then seeded with grasses and clover of good quality and is treated generously a good pasture soon results, which may easily provide feed within one year from sowing.[2]

(*b*) *Eradication by Spraying and Manuring—Chemical Means.*—On grass-land, as on arable fields, "chemical means" resolve themselves into treatment by liquid sprays and the application of artificial manures. Here again, however, the

[1] "Cnicus acaulis," *Jour. Bd. Agric.* (1911), XVII, pp. 907-909.

[2] Carruthers, W. (1906), "Buttercups in Pastures," *Jour. Roy. Ag. Soc.*, LXVII, p. 258.

difference in the requirements of the crops under the two methods of cultivation is so great that the eradication of weeds by chemical means has to be regarded from totally different standpoints in the two cases.

(1) *Sprays.*—On grass-land sprays have only a limited degree of usefulness, because as the herbage consists of a mat of plants which presents in the aggregate a very large area of leaf surface, the amount of spray that is necessary to kill certain obnoxious weeds is sufficient to find a lodgment on the leaves of the herbage and work havoc, particularly among the broader leaved plants, such as clover, which are a most valuable constituent of the crop. . In the majority of cases it is not possible to apply the spray in such a way that it reaches the weeds without affecting the herbage, therefore, generally speaking, this method is of little use on grass-land.

Iron sulphate has been used in an attempt to eradicate dandelions from lawns, the application being repeated till the treatment had to be discontinued for fear of injuring the grass. The experiment was a failure on account of the great vitality of the dandelion roots, which remain unhurt even though the leaves are destroyed by the spray. Iron sulphate has proved equally ineffective with bracken, and copper sulphate is of little or no use to eradicate thistles.

Bracken, on account of its tall branching habit, is more amenable to eradication by spraying than any other grass-land weed. The leafy canopy that it forms offers a large surface which catches and retains the liquid and prevents it from falling to the ground in sufficient quantity to injure the underlying herbage. Sulphuric acid has proved effective in clearing bracken from areas of grazing land. A few hours after spraying with a 5 per cent. solution the bracken leaves wilt, and a few days later the stems turn black and wither, as the acid is gradually conducted along the midrib and down the stalk, eventually reaching almost to the underground rhizome. A second spraying after a new crop has sprung up clears off the bracken for the year and weakens it for future years. The grasses underneath are not much affected, the bracken affording them adequate protection, and as in the following year the fern is slower in making its appearance, the grasses are able to get ahead earlier, with the result that the pasture becomes much improved. Arsenite of soda and salt have also been used with good effect on bracken. Arsenite of soda, however, is inadvisable as a general rule, because it is so very poisonous that there

is danger to cattle that may eat the herbage or hay afterwards. The Americans apply salt solution, using 200 lb. salt per acre, dissolved at the rate of 1 lb. salt in 1½ quarts of water. Two sprayings a year are necessary, and it is claimed that the method is effective.[1] Salt does not injure the herbage, but on the contrary exercises a beneficial action as a manure, so that the salt solution is free from the objection common to most sprays. In Germany a 15 per cent. solution of kainit has been used to eradicate nettles in springtime, and the suggestion is made that this good effect may be due to the presence of salt in the kainit.

(2) *Manures.*—The principles underlying the treatment of grass-land and arable land by manure for the eradication of weeds are essentially different. On arable land the application is made directly to the weeds with a view to burning them up and so destroying them, the actual beneficial action of the manure on the crops being a somewhat secondary consideration. On grass-land, however, it is impossible so to differentiate between weed and crop. In this case the manures are applied with the view to encouraging certain desirable species, to enable them to exercise their full force of competition and so gradually crowd out the undesirable plants.

Apart from their beneficial influence on the herbage, salt and lime, perhaps, exercise a more direct action upon certain weeds. Nettles are less likely to recur if infested pastures are treated with 6 cwts. per acre of salt at the time the weeds are cut down in the spring. A similar dressing in early April is recommended for getting rid of oxeye daisy (*Chrysanthemum leucanthemum*). On the other hand, salt does not seem to injure thistles much, as the effect of various methods of cutting is not enhanced by an after application of salt.[2]

Lime in one of its various forms is usually most effective in reducing the quantity of sorrel (*Rumex acetosa*) and sheep's sorrel (*Rumex acetosella*), though it is still doubtful whether this is due to the fact that the sorrels are intolerant of the lime itself or whether they are merely extremely impatient of the increase of competition due to the improvement of the herbage by the liming. Be that as it may, liming may be regarded as the universal remedy for these weeds. The

[1] Cox, H. R. (1915), "Eradication of Ferns from Pasture Lands in the Eastern United States," *U.S. Dept. Agric., Farmer's Bulletin*, No. 607, p. 12.

[2] "Destruction of Thistles" (1908), *Report of Field Experiments at Harper Adams Agric. Coll.*

quantities used vary considerably, the nature of the soil being the determining factor in many cases. As much as 5, 10, or 15 tons per acre have been applied to very light soils, deficient in lime, but the difference in favour of the very heavy dressing is not considerable. A more general application is about 30 cwts. per acre on light land, ranging up to 3 tons per acre where the soil is heavy and wet. Sheep's sorrel will also yield to basic slag on heavy land, probably on account of the lime in the slag. If docks (*Rumex crispus* and *R. obtusifolius*) are present in pastures they should be spudded out, and if a pinch of sulphate of ammonia be placed on the cut ends the roots are almost certain to be destroyed.

False brome or tor grass (*Brachypodium pinnatum* and *B. sylvaticum*) is sometimes a great pest on down pastures, where its coarse growing tufts seriously depreciate the grazing value of the land. Gas lime has proved an effective remedy when about 2½ cwts. per perch (20 tons per acre) are applied in as fresh a state as possible to the tufts of grass.[1] If spread in autumn, not later than November, the false brome is soon completely killed. The following spring the land needs harrowing and working up to a fine tilth, when a mixture of good grass seeds, suitable to the particular soil, must be sown to provide a fresh turf. Gas lime is most powerful when freshly made, and loses strength rapidly with exposure, especially during rainy weather.

In Cornish experiments, pasture infested with moss was cleaned by suitable treatment with new superphosphate of 28 to 30 per cent. strength. A single application of 6 cwts. per acre in February was sufficient where only a little moss was present, and even when the moss was of long standing, forming a dense carpet an inch thick, a second dressing was completely effective. It is recommended that the superphosphate be followed with a similar dressing of bone meal applied the following autumn, in order to encourage the growth of herbage and discourage a fresh invasion of moss.[2] At Wye, on chalky soil, chemical dressings proved of little use, but mechanical

[1] Hutchinson, H. P. (1912), "Tor Grass or False Brome and its Eradication from Down Pasture," *Jour. Bd. Agric.*, XIX, pp. 648-657.

[2] "Destruction of Moss." (*a*) Cornwall County Council, *Memoranda of Results of Agric. Experiments*, 1903 and 1904, pp. 32-34. (*b*) Cornwall County Council, *Notes on Agric. and Poultry Experiments*, 1905 and 1906, pp. 19-20.

treatment by rolling, harrowing, and the treading of sheep was more efficacious in eradicating moss.[1]

(*c*) *Destruction of Weeds by Parasites.*—Weeds, in common with other plants, are liable to attack by various insect and plant enemies, and some attempt has been made to turn this susceptibility to account in their eradication. Comparatively little work has yet been done in this direction, but definite experiments have been made in New Zealand and Italy and probably elsewhere. Creeping thistle (*Cirsium arvense*), even in this country, is very often attacked by rust, which powders the leaves and stems with dusty brown spots and greatly weakens the plants. Cockayne[2] states that if the rust is to be made an adequate means of control it is necessary to increase infection considerably beyond that occurring naturally. It is possible to cultivate the spores of the rust on thistle leaves under artificial conditions. These rusted leaves are crushed up in water to liberate the spores and the liquid is sprayed on to the thistles in their early stages of growth. Under these conditions it is said that infection is virulent and the disease spreads rapidly.

Italian investigators point out that such common weeds as thistle, sowthistle, bindweed, poppy, bladder campion, hawkbit, charlock, willow-weed, and broomrape are under natural conditions frequently attacked by parasites, and they suggest that with due encouragement a useful means of weed eradication lies at hand. Much care would have to be taken, however, if any great extension of this method were attempted. Many of the weed parasites may be capable of carrying on existence on other hosts, and crops might easily be attacked by the disease employed to kill the weeds. Also, many of the fungus diseases of plants go through two phases of existence on two utterly different hosts, like the wheat rust, which passes one phase on wheat and the other on such plants as the barberry. It would therefore be necessary to investigate the life history carefully in every case, in case the parasite used for killing the weeds should be one that spent another life phase on a useful crop. This danger is a very real one, and some workers suggest that it would be more advisable to encourage insect pests which hinder the spread of weeds by riddling the seeds

[1] A. D. H. (1900), "Moss in Pastures," *South-Eastern Agric. Coll. Journal*, No. 9, pp. 71-72.

[2] Cockayne, A. H. (1915), "Californian Thistle Rust (*Puccinia suaveolens*)," *New Zealand Jour. Agric.*, XI, No. 4, pp. 300-302.

and so destroying their power of germination. The seeds of bindweed, gorse, and some species of wild pea are often so badly attacked that it is difficult to find an uninjured seed. At best this method would be of limited value, some of the worst weeds, such as wild oat (*Avena fatua*), being apparently immune from the attacks of any kind of parasite, whether animal or fungus.

CHAPTER IV.

VITALITY OF WEED SEEDS.

FROM very early days the length of time that seeds retain their power of germinating and forming new plants has been of interest to those engaged in husbandry. Even Theophrastus (about 322 B.C.) recorded that most seeds remained alive for more than three years, and that at Patra, in Cappadonia, seed was said to remain fertile and fit for sowing for forty years. In those days the differences in the behaviour of seeds of the same species in this respect was attributed to the situation, and seeds in elevated places exposed to plenty of wind and sun were supposed to keep longer than others. Nowadays the differences are attributed more to the conditions of storage than to anything else, and it is realised that temperature, moisture in the air and in the seed, the composition of the surrounding atmosphere, and various other factors all play their part in determining how long a seed will live.

Popular superstition, fostered by the reports of the germination of "mummy" wheat, attributes a marvellous longevity to seeds. Strict inquiry and experiment, however, shows that authentic seeds from the ancient sepulchres and pyramids will not germinate, the seeds obtained from such situations which do grow having been proved to be frauds inserted by the Egyptian fellaheen for the sake of gain. In all other cases in which very old seed is reported to have germinated doubt has been thrown on its authenticity.

With a view to ascertaining the approximate time that seeds may be expected to live under conditions of dry storage a British Association Committee[1] carried out a series of experiments with over 200 very varied species of plants, including a number of common wild plants and farm weeds. The range of years is well shown by the following table :—

[1] Strickland, H. E., Daubeny, Henslow, and Lindley (1850, 1857), "Reports of a Committee Appointed to continue their Experiments on the Growth and Vitality of Seeds," *Rep. Brit. Ass., Adv. Sci.*, No. 20, pp. 160-168; No. 27, pp. 43-56.

Limit of Years during which Germinating Capacity was Retained.	Number of Species.
43	1 (Leguminosæ).
42	1 (Leguminosæ).
27	7 (5 Leguminosæ, 1 Malvaceæ, 1 Tiliaceæ).
26	4
25	4
21	4
18	1
15	2
14	1
13	5
12	2
10	4
9	2
8	70
6	3
5	3
4	9
3	97

It is thus seen that the majority of seeds do not survive for many years under ordinary conditions of storage, and that eight and three years seem to be the critical periods for a large number of plants. The actual periods of survival for the wild plants and farm weeds tested in these experiments may prove interesting :—

	Latin Name.	English Name.	Number of Years.
(1)	*Ulex europæus*	Gorse	15
(1)	*Convolvulus major*	Greater bindweed	14
(1)	*Æthusa cynapium*	Fool's parsley	8
(2)	*Anagallis arvensis*	Scarlet pimpernel	8
(3)	*Arctium lappa*	Burdock	8
(4)	*Carum carvi*	Caraway	8
(5)	*Daucus carota*	Wild carrot	8
(6)	*Nepeta cataria*	Catmint	8
(7)	*Œnanthe crocata*	Hemlock water-dropwort	8
(8)	*Rumex obtusifolius*	Broad-leaved dock	8
(9)	*Silene inflata*	Bladder campion	8
(10)	*Vicia sativa*	Common vetch	8
(1)	*Conium maculatum*	Hemlock	5
(2)	*Valerianella dentata*	Narrow-fruited corn salad	5
(1)	*Bryonia dioica*	White bryony	3
(2)	*Hypericum hirsutum*	Hairy St. John's wort	3
(3)	*Plantago media*	Hoary plantain	3
(4)	*Tragopogon porrifolius*	Purple salsify	3
(5)	*Valeriana officinalis*	Common valerian	3
(6)	*Verbascum thapsus*	Great mullein	3

As the above tables show, the seeds of some leguminous plants are able to live for many years under conditions of dry storage. An additional proof was afforded by a number of seeds obtained from the Natural History Museum through the kindness of Dr. Rendle, the keeper of the Botanical Department. These were tested at Rothamsted in 1916, and one seed of black medick (*Medicago lupulina*) gathered in 1884 grew well, though other tested seeds of similar age did not germinate. Many weed seeds are able to retain their vitality under most adverse circumstances, and even when they are swallowed by animals or birds large numbers pass through the alimentary tracts unharmed. This has been definitely proved by many experiments. In a single day a cow was estimated to have eaten with her fodder 89,000 seeds of plantain and 564,000 seeds of chamomile.[1] Of these 85,000 and 198,000 respectively were voided in the dung, apparently uninjured, and the germinating capacity of the seeds then proved to be 58 per cent. and 27 per cent. Dorph Petersen[2] fed seeds of ribwort plantain (*Plantago lanceolata*) and mayweed (*Matricaria inodora*) to a cow, and found that after passing through the digestive system of the animal 51 per cent. and 26 per cent. respectively germinated out of the total number of seeds fed. About 50 per cent. each of sheep's sorrel (*Rumex acetosella*) and fat hen (*Chenopodium album*) passed unharmed through a pig, and 15 per cent. of each through a fowl, although the majority of seeds are usually destroyed in the latter case because of the grinding action in the gizzard. In another case in America a cow and a horse were each fed with 2 lb. of grain screenings in addition to their other food each night and morning for seven days.[3] On the evening of the seventh day they were bedded with sawdust and the excreta for that night collected. The dung and sawdust were thoroughly mixed and put in boxes in a greenhouse and four weeks later the following seeds were found to have germinated and grown :—

[1] Hansen, K. (1911), "Weeds and their Vitality," *Ugeskrift for Landmaend*, 56, pp. 149-151. See *Internat. Review of Agric.*, 1911, p. 738.

[2] Dorph Petersen (1910), *Jahresbericht der Vereinigung für angewandte Botanik.*, Summ. in *Jour. Bd. Agric.*, XVIII, 1911, pp. 599-600.

[3] Patterson, H. J., and White, H. J. (1912), "By-Product Feeds," *Maryland Agric. Expt. Station Bull.*, No. 168, pp. 2-3.

Cow's Dung.	Horse's Dung.
149 Fat hen (*Chenopodium album*)	1213 Fat hen
12 Pigweed	11 Pigweed
14 Bindweed (*Convolvulus arvensis*)	12 Bindweed
4 Foxtail (*Alopecurus pratensis*)	28 Foxtail
2 Timothy (*Phleum pratense*)	6 Timothy
	3 Clover, *Trifolium* sp.
	5 Mustard, *Brassica* sp. (morning glory).
	2 *Convolvulus* sp.

It thus seems that more weed seeds are destroyed by passing through the digestive system of a cow than of a horse. Experiments in India also show that fat hen seeds are not injured by being fed to bullocks,[1] and in this way animals do a good deal towards spreading weeds over considerable areas. Seeds are also able to survive after being eaten by birds, as shown by various authorities.[2] [3]

When, however, weed seeds are buried and stored up in manure heaps many of them succumb, as they are unable to withstand the high temperature generated in a well-made heap. The excessive moisture, together with the acrid nature of the liquid, may also have much to do with the destruction of the weeds, experiments having shown that certain seeds, such as dodder, lose much of their germinating capacity when they are immersed in liquid manure or even pure water for any length of time.[4] Even if they are only slightly buried beneath the surface, the majority of dodder seeds perish in well-made manure in about a month, only a small percentage retaining their vitality. On the other hand, it is not safe to assume that all weed seeds are killed by storing in manure. Experimental results are not available, but it is exceedingly probable that many seeds escape, as many of them are protected by stout outer coats which enable them to resist the adverse conditions. The seeds of fat hen (*Chenopodium album*) not only survive, but germinate and flourish exceedingly on manure heaps.

To the farmer and gardener the most important aspect of

[1] Milne, D. (1915), "The Vitality of Seeds Passed by Cattle," *Agric. Jour. India*, X, pp. 353-369.

[2] Collinge, W. E. (1913), "The Destruction and Dispersal of Weed Seeds by Wild Birds," *Jour. Bd. Agric.*, XX, pp. 15-26.

[3] Kerner, A., and Oliver, F. W. (1895), "Natural History of Plants," pp. 863-865.

[4] Morettini, A. (1914), *Le Stazioni sperimentali agrarie italiane*, XLVII, pp. 733-751.

the vitality of seeds is their power of surviving for prolonged periods when buried in the soil. It is beyond question that weed seeds will lie dormant underground for several years, starting into growth whenever favourable conditions occur, though much discrepancy exists in the estimates of the time that the seeds can endure burial without losing their power of growth. A most striking instance of the abundance of living weed seeds in cultivated soil is afforded by the Somme battlefield. A. W. Hill[1] reports that in July, 1917, acres of poppies were in full flower, forming a stretch of flaming scarlet over wide areas. The poppies were occasionally replaced by a few acres of white chamomile (*Matricaria chamomilla*) and large patches of yellow charlock (*Brassica sinapis*) also broke the uniformity. The subsoil of the area is chalk, covered with loam, and the constant shelling has churned the ground up and incorporated the soil and subsoil very thoroughly. The charlock was specially conspicuous on the more recently dug graves of soldiers, where the pure chalk had been brought up to the surface. On the sites of wrecked woods, sheets of rose-bay or fireweed (*Epilobium angustifolium*) were conspicuous, and round the edges of the ponds formed by shell holes were bands of toad rush (*Juncus bufonius var. gracilis*), accompanied by willow weed (*Polygonum persecaria*), the latter often growing out of the water. In addition to these dominating plants, a large variety of other common arable weeds were present in greater or less amount. It was obviously impossible that these hordes of weed seeds could have been carried by any known means of transport, whether by wind, animals, birds, vehicles, or human beings, and the inference is that they were all present in the soil in great numbers and seized the opportunity to germinate provided for them by the unwonted upheaval of the soil.

On a small scale a similar phenomenon is familiar to almost every farmer. It is a matter of common knowledge that if arable land is turned up rather more deeply than usual, or if old leys are ploughed up, in the following season large quantities of weeds will appear from seeds which must have been buried in the soil awaiting their chance. Belief goes further, and it is often said that large crops of poppies, charlock, or similar weeds spring up even when "old pasture" is ploughed. In-

[1] Hill, A. W. (1917), "The Flora of the Somme Battlefield," *Kew Bull. Misc. Information*, Nos. 9 and 10, pp. 297-300.

quiry often shows that this old pasture has been under arable cultivation at some time or other, thus accounting for the presence of arable weed seeds. Nevertheless, there are many puzzling cases in which no history of arable cultivation can be traced. Where this occurs at a distance from other arable fields, as sometimes happens when moors are reclaimed, it seems that of necessity the seeds must be carried to the spot on a large scale by some means of transport hitherto undetected. As a general rule, however, the presence of seeds buried in the soil is sufficient to account for the large weed crops. By experiment and observation much information has been gathered as to the ability of various weed seeds to withstand burial, but even yet our knowledge of the matter is very incomplete, both as regards the species concerned and the means by which the seeds adapt themselves to the conditions of burial.

A striking characteristic of the majority of farm weeds is the abundance of seed that is produced. Only a very small proportion of this seed finds itself immediately under conditions suitable for germination, and the greater number of seeds are compelled to remain dormant or else to perish. These waiting seeds do not all remain on the surface of the ground, large numbers being carried underground by various agencies. Some of these agencies are well known, but others are easily overlooked. The various means of burial have been summed up by Woodruffe Peacock from his own observation as follows:—[1]

(1) *Means Influenced by the Activity of Human Beings and Domestic Animals.*—Spade, plough, and foot pressure by stock. Cattle drive seeds in 5 inches, horses 3 inches, sheep 2 inches or more, while wheel ruts carry seeds down 10 inches in some cases.

(2) *Environmental Means.*—

(*a*) Wind, including local whirlwinds and storm columns.

(*b*) Water, which, however, usually destroys fertility.

(*c*) Mammals, as fox, rabbit, squirrel, polecat, Norway rat, mole, water vole, stoat, weasel, badger, long-tailed field mouse.

(*d*) Birds.

(*e*) Insects, as ants, burrowing insects, larvæ.

[1] I am indebted to the Rev. E. A. Woodruffe Peacock for the loan of unpublished MSS. containing this information.

(*f*) Worms, which help to bury seeds 4 or 5 feet, especially smooth or rolling seeds like those of charlock, clovers, thistle and broom.

(*g*) Sun and earth cracks, in which, however, most seeds perish.

(*h*) Rock cracks.

Other means may suggest themselves, but the above list is sufficiently comprehensive to indicate the great variety of ways in which seeds may be carried underground to considerable depths.

When once burial has taken place the conditions determine whether the seeds lie dormant or start into premature growth and perish. It seems probable that most of the seeds in the top few inches of soil are in the presence of sufficient water, air and warmth to enable them to germinate, and it then depends upon the vigour of the seedlings and the relative depth of burial whether the young plant can reach the surface or whether it perishes ignominiously, stifled at birth. The deeper buried seeds, however, seem to be able to set up some condition of equilibrium with their surroundings, and instead of germinating many of them lie dormant, awaiting some turn of events that will bring them into more favourable circumstances. Waldron[1] buried seed for several years and then tried to germinate them, and found that the deeper buried seeds, up to a depth of 10 inches, were the better preserved. As years go on numbers of the buried seeds rot and perish in other ways, but a certain number survive for long periods of time. Very definite evidence that this is the case is provided by the crops of weeds that spring up when methods of cultivation are altered.

An instance has recently occurred in Cumberland. Forty acres of land covered with gorse and heath were broken up in 1893 and kept clean under arable cultivation for over ten years. Between 1904-06 the land was laid down to grass, and gorse seedlings soon appeared. These were stubbed out without being allowed to seed and no more appeared on the pasture. In the winter 1917-18 the area was ploughed up and sown with oats, and gorse seedlings soon reappeared. At harvest time they were abundant in the stubble, being most plentiful where the gorse was originally thickest. These

[1] Waldron, L. R. (1904), "Vitality and Growth of Buried Weed Seeds," *North Dakota Agric. Coll. Bull.*, No. 62. Also see Munerati, O., and Zapparoli, T. V. (1913), *Le Stazioni sperimentali agrarie italiane*, Vol. XLVI, pp. 347-371.

seeds had been buried for twenty-five years, and still retained their power of germinating as soon as conditions became more favourable.[1]

In farming practice the seeds of broomrape (*Orobanche sp.*) are credited with the power of lying dormant for several years and germinating in succession. This has been corroborated by pot experiments carried out for a period of fourteen years, which showed that broomrape seeds are able to retain their vitality when buried in soil for eight years.[2] Other workers give the period as at least ten years, the variation being probably due to differing conditions.

From the practical standpoint the case is very clear that many weed seeds have the power of remaining buried for a long time without perishing, but in the absence of definite experimental and historical evidence many fantastic ideas on the subject have gained credence. With a view to obtaining some definite facts a series of experiments have been carried out with soil from the Rothamsted fields, of which the detailed history for many years past is accurately known.[3] Old arable fields were selected which had been grassed over for fifty-eight, forty-three, thirty-two, and ten years, while Harpenden Common, Park Grass (a piece of old pasture that is known to have been under grass for at least 300 years), and also a field that has long been ploughed, were used for comparison. Samples of soil, 6 inches square, were taken inch by inch to a depth of 12 inches, the utmost care being used to avoid contamination from surrounding soil. These samples were placed in shallow earthenware pans and boxes in a greenhouse, kept moist and watched for about two years. As seedlings appeared they were identified and removed to make way for later comers.

As was to be expected a large number of the seedlings were those of typical grass-land plants, derived from seeds from the covering herbage. No idea could be formed of the age of these, so they were perforce left out of consideration. The "real old pasture" from the Common and Park Grass yielded all told six seeds of typical arable weeds, whose presence could readily be accounted for by accidental carriage on the feet of horses, cattle, human beings, wheels, birds, etc. All the old

[1] Parkin, J. (1918), "Vitality of Gorse Seed," *Nature*, 2552, Vol. 102, pp. 65-66.

[2] Passerini, N. (1910), "Duration of Vitality of Seeds of *Orobanche crenata*," *Atti R. Accad. Econ. Agr. Georg. Firanze*, 5, ser. 7, No. 1, pp. 1-7.

[3] Brenchley, W. E. (1918), "Buried Weed Seeds," *Jour. Agric. Sci.*, IX, pp. 1-31.

arable fields, even the one that had been under grass for fifty-eight years, yielded arable weeds in such numbers as to preclude the possibility of accidental infection after the land was grassed over. One is therefore forced to the conclusion that the seeds had lain dormant throughout the years.

The grand total of typical arable weeds obtained from the samples are given in the following table :—

Methods of Cultivation.	Area.	Years under Grass.	No. of Samples.	Total Number of Arable Weeds.
Real old pasture . .	Harpenden Common	?	3	2
,, ,, ,, . .	Park Grass	?	4	4
Old arable land . .	Lab. House Meadow	58	4	30
,, ,, ,, . .	Barn Field Grass	43	4	12
,, ,, ,, . .	Geescroft	32	4	74
,, ,, ,, . .	New Zealand I.	10	4	457
,, ,, ,, . .	New Zealand II.	10	4	334
Present day arable land	Long Hoos	0	2	782

The above table shows that after ten years of burial very large numbers of weed seeds are still alive and capable of springing into activity as soon as circumstances are favourable. The number decreases with time, but even after thirty years or more it is still great, as 74 seeds from an area 1 foot square by 1 foot deep implies a surprisingly large total per acre. Still longer periods of burial fail to destroy all the seeds, though the number of live seeds decreases considerably. The greater number of the arable weed seeds were found several inches below the surface, and many of them were resting as far down as twelve inches. The actual number found at the different depths are shown in the following table :—

Total Numbers of Arable Weed Seeds from Different Depths.

Area.	Period under Grass. Years.	Depth in Inches.												Total.
		1	2	3	4	5	6	7	8	9	10	11	12	
Lab. House Meadow .	58	2	6	6	5	9		1	1					30
Barn Field Grass	43		1				3	3		4		1		12
Geescroft . .	32	1	2	3	5	9	14	12	8	9	2	6	3	74
New Zealand I.	10	68	51	57	67	53	36	17	16	13	44	9	26	457
New Zealand II.	10	57	46	51	36	48	30	14	16	7	16	13		334
Long Hoos .	0	60	92	162	97	115	82	63	40	21	29	8	13	782

The number of species found at different depths is also very instructive. As might be expected, in present day arable land and land that has been grassed over for comparatively short periods most of the species are represented in the top six or seven inches, a less number occurring at lower depths. When the land has been under grass for longer periods, however, many of the arable species tend to disappear from the upper few inches, as most of the seeds have either been carried lower or have started into growth and perished. An apparent exception to this is seen in the Laboratory House Meadow, but in this case, as the meadow is close to the house, doubt is thrown on the age of some of the buried seeds in the upper inches, owing to the proximity of allotments.

Distribution of Species of Buried Weed Seeds.

Area.	Total Number of Species Occurring.	Number of Species Occurring at Different Depths.											
		Depth in Inches.											
		1	2	3	4	5	6	7.	8	9	10	11	12
Lab. House Meadow . .	11	2	4	4	3	5		1	1				
Barn Field Grass	4		1				2	1		1		1	
Geescroft . . .	9	1	1	1	2	5	2	3	2	3	1	4	3
New Zealand I	14	9	9	9	9	11	9	7	6	2	3	2	1
,, ,, II	13	9	11	10	9	10	9	4	3	2	1	2	
Long Hoos . .	20	10	12	12	11	10	13	11	13	9	6	6	6

The number of species of weed seeds that are obtained by this method after burial for ten years and more is somewhat limited. After the shorter periods large numbers of certain species are found, especially orache (*Atriplex patula*), poppy, knotgrass (*Polygonum aviculare*), field speedwell (*Veronica tournefortii* and *V. agrestis*). As time goes on the poppies and speedwell drop out almost entirely, but orache and knotgrass are still plentiful even after many years of burial.

In view of the fact that large crops of charlock are expected and often obtained when grassed-over arable land is ploughed up it is interesting to notice the evidence of the survival of this weed in this experiment.

Brassica sp. *Charlock.*

Area.	Period under Grass. Years.	Number of Seedlings from Samples.
Lab. House Meadow	58	1
Barn Field Grass	43	3
Geescroft	32	—
New Zealand I	10	11
„ „ II	10	11
Long Hoos	0	16

The number of seeds was not great, but as each charlock plant grows large and is very conspicuous, it is probable that quite sufficient would be present to make a good show if the land were again ploughed. As a matter of fact, New Zealand was broken up immediately after the samples had been taken, and the following season an abundance of charlock smothered the field, together with large quantities of ivy-leaved and field speedwell, with poppies locally. The great decrease in the number of live charlock seeds as the period of burial lengthened does not indicate that this particular seed is any better fitted to survive under such conditions than many other species that are less striking in appearance. The Rothamsted records in several cases give details of the weeds that occurred on the fields sampled when they were originally under the plough, and a comparison of these with the seedlings obtained in the pans shows a close resemblance, thus further strengthening the theory that the weeds in the pans had sprung up from seeds that had remained alive though buried for years. The occurrence of seedlings of creeping thistle (*Cirsium arvense*) is of interest, as farmers often maintain that the seeds of this plant are abortive and never germinate (Fig. 25).

FIG. 25.—SEEDLING OF CREEPING THISTLE (*Cirsium arvense*) which came up from Seed Buried in Soil from New Zealand Field at Rothamsted.

The reasons why seeds buried in soil should retain their

power of germination longer than those kept in dry storage or those on the surface of the soil are still rather obscure. The question is complicated and probably depends upon a certain balance being reached between the various physiological conditions in which the seed finds itself. The temperature is more equable some inches below the surface of the soil, and while seeds near or on the surface may perish from cold during the winter, buried seeds do not usually suffer from extreme cold. Strong sunlight may also be very injurious to germination, and this again is ruled out.[1] The stage of maturity is another important factor. Immature seeds soon perish, but mature and properly ripened seeds contain just enough water to enable them to lie dormant, and the conditions of air and moisture surrounding them in the soil seem to be such as to enable them to mark time without undergoing further desiccation or other vital changes. When once the long buried seeds are brought to the surface they are likely to start into growth very quickly. Experiments have shown that many species of seeds that have been kept in unfavourable circumstances germinate rapidly when the conditions are improved,[2] for instance, when they are brought from prolonged darkness into light. On the whole, the more deeply buried seeds retain their germinating capacity the best, as was clearly shown by the Rothamsted experiment above described and also by pot experiments carried out by Dorph Petersen with various seeds buried 3, 6, and 12 inches below the surface.

Much more information and evidence are needed before it will be possible to explain fully why large crops of certain weeds, as charlock, poppies, and fireweed, spring up when land is ploughed or cleared even when the weeds were not present before the change of conditions. It is, however, quite clear that in the majority of cases sufficient live weed seeds are buried in the soil to supply far larger crops of weeds than any farmer need desire.

[1] Gümbel, H. (1912), Untersuchungen über die Keimungverhältnisse verschiedener Unkräuter, *Landwirtsch. Jahrb.*, XLIII, pp. 215-331.

[2] Praktische Blätter für Pflanzenbau und -schutz (1912), Summ. in *Jour. Bd. Agric.*, XIX, pp. 231-232.

CHAPTER V.

HABITS OF WEEDS.

THE habits of growth and the length of time that weeds live have much to do with the methods adopted in dealing with them, and also with the amount of damage that they are able to inflict upon crops. A knowledge of the way in which a particular weed grows is often a valuable asset to the farmer, enabling him to eradicate it in the most effective way, and in some cases an understanding of the life history of a plant reveals some weak point in development at which it may most readily be attacked with every hope of success.

Duration of Weeds.—Weeds may be divided into three classes according to the length of time they live:—

(1) *Annual Weeds.*—These are plants in which the whole cycle of existence is completed within twelve months. After germination the vegetative growth is rapid, so that the plant is in flower within a comparatively short space of time. The ripening of the fruits is equally rapid, and the production of seed is thus ensured. Annual weeds depend entirely upon seed for their reproduction, and the whole energies of the plants are directed towards the formation of this essential. As a general rule the quantity of seed produced is very abundant, so that even though much of it may be lost by decay or other means a sufficiency is left to carry on the species. If the season be hot and dry, and there is danger that plant life will suffer from drought, the annual weeds hurry into flower at an early stage of development in order that they may not die before their seeds are formed. It is no uncommon sight in a dry summer to see the most miserable specimens putting up a weak flower and then ripening miniature seed pods. The same effect is produced by other adverse circumstances, such as the presence of poisonous substances in the soil. Unless they are killed outright, annuals strive to the very utmost to produce some stock of seed before they give

up the struggle for existence. This habit of life makes it quite easy to eradicate annual weeds by careful cultivation. If the seeds are allowed to germinate and the young plants are cut down before they flower, seed formation is prevented and the plants have no other means of reproducing themselves. It is necessary to keep a careful watch because some plants, such as ivy-leaved speedwell, chickweed, shepherd's purse, pimpernel and others begin to flower very early in life, and these early flowers ripen and shed their seeds long before the latest formed buds have opened. Many of the arable weeds are annual in duration, some of the most common being groundsel, spurry, poppy, chickweed, speedwells, pimpernel, charlock, radish, thyme-leaved sandwort, fat hen, spurge, fumitory, and cleavers, but the commoner weeds of grass-land usually live longer, as the short-lived plants find it difficult to establish their transitory existence under the conditions found in pasture or meadow land.

(2) *Biennial Weeds.*—These are plants which spread their life cycle over two years. In the first season the seed germinates and vegetative growth is active, but flowers are not produced. In many cases large quantities of reserve food substances are laid up during this time and stored away in the roots or underground stems for use during the following year. In the second year the energies of the plant are directed to seed formation, the reserves of food being used up for the purpose of developing the flower and fruits. When this is safely carried out the plant dies exhausted.

If a biennial plant starts growing early in its first year, and the summer is hot and dry, it often happens that flower formation is hastened. Under these circumstances, instead of waiting till the second year, the flowering spikes are thrown up and seed is produced at the end of the first season, so that the weed becomes an annual for the occasion. The object of this change of habit is, once again, to ensure seed formation, for the biennials are as dependent as are the annuals on seed for the propagation of their kind, not being provided with means of vegetative reproduction.

Very few weeds are truly biennial in habit, as they labour under such serious disadvantages. The cultivation of the soil during the growing season prevents the plants from making much growth and from storing up food to tide them over the winter. Even if they do escape for the time, it is more than probable that spring cultivation will cut them up before

they have any opportunity of flowering and seeding. As they have no other means of propagation it is obvious that biennials have a very poor chance under these circumstances except in the isolated cases in which for any reason a change to an annual habit is made. Consequently few or no biennials are to be found among arable weeds, and even those of grass-land are few in number, the most noteworthy being wild carrot, spear thistle and marsh thistle, the hemlock from the border of the fields being similar in type.

(3) *Perennial Weeds.*—These are plants which have no definite term of existence, but which, when once established, and if left to their own devices, live on from year to year, constantly spreading and increasing in quantity. All of them can and do arise from seeds, but they are by no means dependent on this method for their perpetuation. Perennials have various arrangements for vegetative reproduction whereby new plants can arise from different portions of the original parent without the intervention of seed. They also form thickened and creeping underground stems, bulbs, or strong bulky roots, in which quantities of food are stored up for the use of the plant when necessary. Most of the perennial farm weeds die down to the surface of the ground in the winter but live on in their buried parts, and then, in the spring, the stored up food is utilised to give the plant a fresh start and to carry it on until the new aerial stem and leaves are able to take up the work of nutrition. Fuller details of the habit of the perennials will be found under the next heading "Habits of Growth of Weeds," especially in sections 3, 5, 6, 8, 9.

Habits of Growth of Weeds.—Farm weeds vary much in their habits, so that for every condition of life weeds are found to suit the particular circumstances. Broadly speaking, annual plants adopt one set of habits and perennials another, but this is not an absolutely hard and fast rule. It is not always possible to be quite certain how to classify some weeds, as their mode of growth may combine the characteristics of two classes, and the following grouping must only be regarded as a broad and general division, which is liable to be modified by different observers or by the same observer at different times and places.

(1) *Erect Weeds.*—Under this heading may be classed all those weeds which throw up an erect stem, more or less branched, bearing leaves, flowers and fruit. Nearly all weeds

of this type are annuals and develop either a tap root or a more fibrous root which does not thicken up to any great extent, e.g. charlock, spurge, fat hen, wild radish, nipplewort, corn marigold, corn cockle, groundsel, shepherd's needle, poppy, red dead nettle, corn buttercup, and others.

In a few perennial plants, as pignut and bulbous buttercup, the same erect habit of growth is adopted, but the base of the stem is considerably swollen and serves as a storehouse of food from year to year. Some of the erect weeds make big plants and have large leaves, and as they grow up with the crop rob it of a good deal of light as well as taking up food and water from the soil.

(2) *Tufted Weeds.*—These grow close to the ground and often branch considerably, forming a close tuft of leaves and stems that is very characteristic in appearance. Most are annual in duration: lady's mantle, mouse-ear chickweed, swine cress and annual meadow grass are the most familiar examples. In some situations the three former have a tendency to send out longer branches, so that this group merges into the next. Spurry, annual knawel, mayweed, and chamomile also grow near the ground and branch repeatedly, and may be included in this section.

(3) *Weeds with Stems Trailing over the Surface of the Ground, but not Rooting at the Nodes.*—Some of the most troublesome annual weeds come into this section, and given favourable circumstances a single plant is able to cover a large area of ground. Each weed possesses a single main root, and sends out horizontal branches which again branch repeatedly until at length a dense mat is formed which effectually covers the surface of the soil and prevents the ingress of light and air. A single plant of orache seen in the summer of 1918 at Helmingham in Suffolk measured over 4 feet in diameter, and it needs little imagination to realise that no other vegetation, whether weed or crop, had any opportunity of flowering within the area covered by this plant. The trailing weeds are very troublesome among roots, as they tend to cluster round the young plants and are not removed by hoeing, so that unless they are carefully taken out by handweeding the crop has little chance, for root crops are very impatient of overcrowding, particularly in the earlier stages. Knotgrass, chickweed, speedwells of various species, orache, pimpernel, and wild pansy are plentiful on arable land, and several kinds of trailing geraniums occur as weeds on leys, where they are harmful

because they make the grass patchy by choking it out wherever they grow.

(4) *Rosette Weeds.*—The characteristic feature of these weeds is that no leafy stem is produced, but a number of leaves arise together from a rootstock or much compressed stem lying just below the ground level. In some cases, as in the daisy, dandelion, and plantain, the naked flowering stems arise in the same way, but in others, as in shepherd's purse and the various docks, a leafy flowering shoot is thrown up. Two types of rosettes may be distinguished, but the habitat often determines which type will be produced by a particular species of weed.

(*a*) Rosettes in which the leaves have little or no leaf stalk and the blades are pressed close to the ground, as in daisy, shepherd's purse, hoary plantain, and sometimes the greater plantain.

(*b*) Rosettes in which the leaves may or may not have leaf-stalks, but in which the blades are somewhat raised from the ground, forming a cluster rather than a true rosette, as in dandelion, docks, ribwort plantain, and greater plantain (usual form).

The first type of rosette causes much trouble in grass-land, because all vegetation is choked out from underneath the weeds, and as the latter often occur in large numbers and continually spread, infested pastures rapidly deteriorate in quality unless measures are taken to check the invaders.

Most of this group are perennial, shepherd's purse being almost the only common annual weed that adopts this habit.

(5) *Weeds Creeping on Surface of Ground and Rooting at Nodes.*—These weeds closely resemble the trailers (3), but are distinguished by the abundant supply of adventitious roots that are developed from the leaf-joints. Most of them, however, are perennials, as the extra rooting system provides for a continual stock of young plants which are able to establish themselves and survive the winter. Creeping buttercup, silverweed, and bent grass are representative of these weeds, but the habit is less common than most of the others.

(6) *Weeds Creeping by Rhizomes or Underground Stems and Sending up Green Shoots above Ground.*—This habit is confined to perennial weeds, and the group includes some of the very worst of the farm weeds. The rhizomes may either creep near the surface as in couch-grass, stinging nettle, corn mint, and rush, or they may descend to various depths, running vertically

or horizontally as circumstances dictate, as in thistle, horse-tail, and coltsfoot. In either case buds are formed which push up above the soil and develop into green shoots, producing leaves and flowers. The food stored underground during the winter is used to start the buds into activity in the spring, and later on the green shoots form an extra stock of food and pass it down below to be stored for the next winter, thus completing the vicious circle. Dormant buds are plentiful on the rhizomes, and if a small piece of the latter is broken off the buds develop, roots and shoots are sent out, and a new plant results. The rhizomes enable the weeds to migrate considerable distances, and when great efforts have been made to clear a particular spot it is no unusual occurrence to find the pest turning up many yards away, perhaps in another field, to which it has travelled and escaped notice.

Coltsfoot is slightly different in habit from the other weeds in this class. Early in the spring, about February, clusters of flower buds are pushed above ground, which give rise to the familiar yellow flowers, somewhat resembling small dandelions. No leaves are produced at this time, but when flowering is nearly or quite over more buds develop from other parts of the rhizomes, and this second set produces the large cottony leaves that often carpet the ground where coltsfoot is abundant. This separation of flower and leaf leads many people into the mistake of thinking that they are not connected, and too often the flowers are allowed to ripen seed with impunity by the very farmers who make determined onslaughts on the plant when the leaves have appeared.

(7) *Climbing and Scrambling Weeds.*—A few plants produce very long, weak stems, which raise themselves into the light and air by twining or scrambling round other vegetation. When these weeds are plentiful among crops they are most troublesome, because they tend to strangle the crop plants and prevent the latter developing properly, and also, if the stems of cereals are weak, the climbing weeds pull them down and cause them to "lodge" without any opportunity of rising again. The worst climbing weeds in this class are convolvulus (or bindweed) and black bindweed. The former is a perennial, with long twisted rhizomes from which an abundance of weak aerial stems are given off, while the latter is an annual whose leaves bear such a similarity to those of the true bindweed that the two weeds are often confused. Both are very leafy, and when they occur abundantly in corn crops it is necessary to

dry the sheaves most thoroughly as the bindweeds are apt to cause heating in the stack.

Vetches occasionally appear as farm weeds, though most of them are typically hedge plants. They are climbers in which the end leaflet of the compound leaf is modified into a tendril. This is irritable and curls round any available support, enabling the weak stemmed plant to drag itself up.

Goosegrass (*Galium aparine*) does not climb, but scrambles over and among the crops, clinging to them by the minute hooked prickles with which every part of the plant is clothed. The slender stems may reach a length of several feet, and their clinging habit causes considerable interference with farm operations. Goosegrass is only an annual, but under suitable conditions it grows very rapidly, forming large numbers of prickly fruits which are very easily picked up and carried about by anything with which they come into contact.

(8) *Weeds with Swollen Internodes.*—This habit, fortunately, is unusual among farm weeds. In the knotty or onion couch the portions of stem between the successive leaves are swollen up into large knobs, several occurring in a string. These are perennial, very tenacious of life, and resistant to most attempts to eradicate them. Every "knot" will produce a new plant, so that if the weed is broken by ploughing it is encouraged to increase. If, again, the clusters of knots are brought to the surface in cultivation and are allowed to dry, they separate into the individual knots, and additional plants result. It is therefore specially important that this weed should be cultivated out with as little breakage as possible, and should be promptly removed from the soil before it dies and breaks up.

(9) *Bulbs.*—The weeds that belong to the Lily family are characterised by bulbs, which are underground clusters of swollen scale leaves springing from a small flattened stem. Buds arise between these scale leaves and develop into new bulbs, and seeds are also produced, so that such weeds as meadow saffron (*Colchicum autumnale*) and Bath asparagus (*Ornithogalum pyrenaicum*) have two certain methods of reproduction. Wild onion possesses a third method, as small bulbils arise among the flowers, which fall to the earth and develop into fresh plants.

(10) *Parasitic Weeds.*—These are few in number, but are capable of working much havoc when they are present among crops. Their habit is to attach themselves, by means of suckers,

to some part of a selected host plant and steadily rob their victim of food. A bad attack of dodder may utterly ruin a clover crop by the constant sapping of strength consequent on the loss of nutritive substances. Yellow rattle, broomrape, and bartsia are the other most familiar parasites, but they are all sufficiently important to demand more extended notice. (See Chapter VI.)

CHAPTER VI.

PARASITIC WEEDS.

ORDINARY green plants use the soil and the atmosphere as storehouses from which they draw the raw materials of their food, these being then converted by the vital processes of the plants into substances which can be utilised to build up the tissues. The roots, by means of fine root hairs, take up from the soil water in which nitrogen (in the form of nitrates), and compounds of such mineral substances as potassium, phosphorus, iron, calcium, magnesium, etc., are dissolved. This dissolved raw food passes up through the woody part of the plant into the leaves, where it meets with supplies of carbon which are taken in from the air in the form of carbon-dioxide. During the daytime complicated chemical changes take place resulting ultimately in the formation of such substances as sugar and starch, which are then conveyed to the various parts of the plant where they are needed. This preparation of food can only go on in green parts in the presence of light, so that plants that do not possess green colouring matter or in which leaves are absent and are not replaced by green stems are not able to prepare their own food, but must obtain it ready for use from some other source. Some plants of this nature attach themselves in various ways to other living plants and steal their food all ready prepared, thus earning the name of *parasitic plants.*

Parasitic plants may be divided into two classes:—

(1) *Total parasites*, in which green colouring matter is entirely absent, and which cannot prepare any food for themselves, so that they are absolutely dependent upon other plants for their food.

(2) *Partial parasites*, which possess a certain amount of green colouring matter which is often very poor in quality; they are able to prepare part of their food, but are dependent upon other plants for most of their nutriment.

Total parasites are capable of doing great harm to the

host plants on which they live, as they drain the hosts of so much food that the latter are necessarily much enfeebled. Partial parasites usually do less harm, because their demands are not so heavy, but they can do much injury if they attack weakly hosts.

Among farm weeds there are a few species that live parasitically, some of which are of real economic importance, while the rest are more interesting than dangerous. Both total and partial parasites are represented, dodder (*Cuscuta spp.*) and broomrape (*Orobanche spp.*) being the chief total parasites, and yellow rattle (*Rhinanthus crista-galli*) and red bartsia (*Bartsia odontites*) the most common partial parasites. In addition to these, eye-bright (*Euphrasia spp.*), cow-wheat (*Melampyrum spp.*) and red rattle (*Pedicularis spp.*) are sometimes found in grassland and are probably partially parasitic on the roots of grasses, but they are not known to do much damage.

FIG. 26.—DODDER (*Cuscuta trifolii*), parasitic on Clover.

DODDER (*Cuscuta spp.*), (Fig. 26), Nat. Order *Convolvulaceæ*.—Dodder is frequently seen amongst clover and gorse, appearing as long, slender red threads which interlace the stems and branches. The threads are not rooted in the ground and they bear no leaves, but are studded in the summer with clusters of small white flowers which are followed by four-seeded capsules or seed vessels. Several species of dodder are scattered over the world, each species having one or more host plants on which it usually lives. Among others the clover dodder (*Cuscuta trifolii*) patronises clover and other leguminous plants; flax dodder

(*C. epilinum*) seems to live entirely on flax ; lesser dodder (*C. epithymum*) on the roots of heath, thyme, and other small shrubby plants, while the common or greater dodder (*C. europæa*) is much less exclusive and is found on a great variety of plants in Europe and parts of Asia.

The seeds of dodder fall to the ground or are sown along with a crop. They start into growth, each seedling develops a small root and sends up a thin delicate stem into the air. This stem twists round seeking for a congenial host, but if this is not found the seedling dies. If a host is available the dodder twists round it and rapidly fastens itself on to the stem by means of suckers ; when connection is established the roots and the lower part of the stem of the dodder die away, leaving the parasite disconnected from the ground and entirely dependent upon the host for its food.

The suckers are small swellings or tubercles resembling the beginnings of roots. They gradually bore their way through the epidermis or outer skin of the host plant, then through the underlying soft tissue or cortex until they reach the central part of the stem. Intimate connection is thus established between the conducting strands of the host plant and those of the dodder, so that a clear passage is available for the transference of food in a ready prepared condition from the host to the parasite. If much dodder is present the drain on the resources of the host is often so severe that the victim cannot stand the strain but dies of starvation, and in this way large areas of clover are often ruined. Dodder is recognised as one of the most dangerous foes of this crop, and therefore legislation is adopted against it, making it an offence to sell crop seed contaminated with dodder seed.

Although most species of dodder are usually associated with one or more well-defined host plants, it is now found that some of them are capable of infecting other plants, including various kinds of weeds. This renders the pest still more dangerous, for dodder, being under favourable circumstances, is often able to pass safely through the winter in the vegetative condition and may succeed in escaping observation on the other hosts even when the main crop has been drastically dealt with. The clover dodder (*Cuscuta trifolii*) has been known to spread on to hoary plantain and bedstraw, the common dodder will spread from nettles to grasses,[1] and another species (*Cuscuta*

[1] Montemartini, L. (1913), Alcune malattie nuove o rare, *Rivista di Patologia vegetale*, VI, pp. 204-210.

arvensis) is found on a variety of weeds as well as on clover, including dock, dog's mercury (*Mercurialis perennis*), sow-thistle, charlock, black nightshade (*Solanum nigrum*), nettle, creeping thistle, wild lettuce, knotgrass, and mayweed.[1]

Dodder seeds retain their power of germination for several years, even when buried in the soil. The germination of the seeds is spread over a long period, the largest percentage coming up during the first month after sowing, while the others appear later on in gradually decreasing numbers. Some of the seeds are "hard" and it is these which form a dangerous stock in the soil for several years after infection. Although dodder seeds will lie dormant in the soil for so long, Italian investigators claim that they are not able to withstand the action of farmyard manure. If they are buried in a heap of manure most of the seeds lose their power of germinating within about a month, only a very small percentage retaining their vitality over longer periods. It is considered, therefore, that there is comparatively little danger of spreading dodder infection by means of farmyard manure, provided the latter is well made and properly treated.

Eradication of Dodder.—In this country clover dodder (*C. trifolii*) is the species that causes most trouble. As prevention is better than cure every effort should be made to sow seed that is absolutely free from dodder seeds. With the exception of an American species (*C. gronovii*), which has extra large seeds resembling in size those of clover, the majority of dodder seeds can be effectively removed from clover and lucerne by screening with sieves of suitable mesh. A large proportion, but not all, of the dodder seeds may also be destroyed by dry heating, as they lose their power of germination at temperatures that are harmless to the associated clover seeds. The most effective temperatures seem to be:—[2]

149° F. for 2 hours.

158° F. for 30 minutes or for 1 hour.

167° F. for 30 minutes or for 1 hour.

If infection does occur and the patches are observed before they have spread too far, the affected part of the crop should be dug up, covered with chaff, sprinkled with paraffin and burnt on the spot. The dodder should not be torn out with a rake, as this serves to spread the trouble. If infected plants

[1] D'Ippolito, G. (1913), *Le Stazioni sperimentali agrarie italiane*, XLVI, pp. 540-549.

[2] *Ibid.*

are noticed during the winter they should be cut off an inch or two below the surface of the soil with a sharp spade or hoe, and burnt on the spot. If this is impossible the plants should be carried away with the greatest care, in order to prevent seeds or pieces of dodder being scattered about the field.

If the infection is too widely spread to be dealt with locally, it is best to plough under the affected crop, burying the dodder, provided seed formation has not begun. If seeds are forming the crops should be cut as low down as possible and burnt. As the clover dodder is usually associated with leguminous plants only, it is advisable to avoid growing such crops for a period of years, in order that the dodder seeds lying dormant in the soil may have an opportunity to germinate and die for lack of a suitable host from which they can obtain their nourishment. During this period the land should be cropped with cereals, grasses, or roots, which the clover dodder does not attack.[1]

In some cases spraying is said to be an effective means of eradicating dodder. It is reported that a 15 per cent. solution of sulphate of iron kills the parasite and also blackens the clover badly, but that the latter recovers and sprouts again. Arsenite of soda, at the rate of $\frac{1}{2}$ lb. in 5 gallons of water has proved successful on lucerne.[2] French experiments[3] also show that heavy dressings of sodium nitrate (8 cwts. per acre) will destroy dodder and at the same time strengthen the alfalfa or other leguminous host, thus enabling the latter to resist the drain of the parasite to a greater degree. Sodium nitrate is advantageous in that it does not exercise the same dangerous burning action on vegetation as sulphate of iron.

BROOMRAPE (*Orobanche spp.*), (Figs. 27, 28), Nat. Order *Orobanchaceæ*.—The lesser broomrape (*Orobanche minor*) is the species of most economic importance in this country as it fastens on the roots of clover, lucerne, sainfoin, and other leguminous crops and sometimes does considerable damage, completely ruining the second cut of clover in some cases. It also attacks a number of other plants which are not

[1] (1906), "Dodder," *Jour. Bd. Agric.*, XIII, pp. 331-338.
[2] (1908), "Eradication of Dodder," *Jour. Bd. Agric.*, XV, pp. 280-281.
[3] Farcy, J. (1910), *Journal d'Agriculture pratique*, No. 42, pp. 497-498.

Fig. 27.—Broomrape (*Orobanche minor*), parasitic on Sainfoin.
Right.—Sainfoin plant not attacked.
Left.—Sainfoin plant attacked by Broomrape, showing the harmful effect on growth.

Fig. 28.—Broomrape (*Orobanche minor*), parasitic on Lucerne.

leguminous.[1] Another British species, branched broomrape (*O. ramosa*), is of more importance in other countries, for instance in America, where it works havoc among hemp crops and also attacks tomatoes.

The parasite appears above ground as a thick fleshy stem bearing a number of flowers which rapidly form seed vessels containing an abundance of very small seeds, which are scattered by the wind. The whole plant is dingy, usually brown or purple in colour, with no leaves and no trace of green colouring matter.

Broomrape seeds can lie dormant in the soil for at least ten years, probably longer. They are apparently unable to germinate unless they are in the immediate neighbourhood of the fine fibrous roots of their proper host, and their power of lying dormant enables them to await suitable conditions without suffering from the delay. Generally speaking, they attack well-developed host plants, as if they attacked young and weakly plants the hosts would be so debilitated by the drain on their resources that the parasite would fail to obtain sufficient food to make satisfactory growth.

The broomrape seed germinates and puts out a small radicle or root which penetrates a fine rootlet of the host and soon connects itself with the conducting strand. This radicle at once begins to steal food from the host, and stores it up in the form of a starchy reserve food in the upper part of the radicle which swells up and gradually forms a nodule on the host root. This nodule increases in size and after a time a number of small prominences appear on its surface, a larger swelling developing just where the seed coat was at first present. The small prominences grow out into roots which surround the nodule closely and attack the host roots in other places, thus providing several points of attachment instead of only one. The larger swelling develops into a shoot, short and covered with scales, which eventually elongates and grows

[1] Garman, H. (1903), *Kentucky Agric. Exp. Stat. Bull.*, 105, p. 31, gives a list of English plants attacked by *Orobanche minor*.

Crepis virens	*Poterium sanguisorba?*
Crithmum maritimum	*Trifolium arvense.*
Daucus carota	,, *pratense.*
Digitalis purpurea	,, *repens.*
Hypochæris radicata	,, *strictum.*
Lotus corniculatus	,, *subterraneum.*
Medicago lupulina	,, *striatum.*
,, *sativa*	,, *filiforme.*

up above the soil to bear the flowers. The greater part of the life of the broomrape is passed below ground, as the nodule spends twelve months or more in developing into a fair sized bulb-like structure, before pushing aerial shoots. After the first crop of clover or lucerne has been cut a good deal of food is stored up below ground, and as the soil is well warmed up at the time, the broomrape on the root thrives on the extra food and warmth, develops very rapidly, and throws up flowering stems which ripen their fruits and seeds within a very short space of time.

Eradication of Broomrape.—The best remedy is prevention, by sowing clean seed. The broomrape seeds are some of the very smallest seeds that occur, so it is an easy matter to screen them out from the large seeds of the crops. If unfortunately infection does occur, the broomrapes should be pulled up by hand immediately they appear above the soil, before they have time to form seed, and should then be burnt. The attachment with the host roots is not very firm, and the whole parasite easily comes away. This procedure must be carried out systematically for several years until the dormant seeds have all developed. It is useless to do it for one or two years only, as a very few plants, if neglected, are sufficient to re-seed a large area. The clover or other crop should be encouraged by judicious manuring and liming, to make it strong enough to withstand the attacks of the parasite, and when the crop is eventually ploughed up no other leguminous plant should be sown on the same ground for several years. The interval should be as long as possible, a case being on record [1] in which broomrape attacked clover after seven years had elapsed since the last clover crop, the new attack being so severe that the whole crop had to be ploughed up.

Broomrape deserves more attention than it usually gets, for many farmers fail to realise the life history of the plant and do not connect the poorness of their second cut of clover with the armies of dingy brown spikes that spring up on their fields.

YELLOW RATTLE (*Rhinanthus crista-galli.*), Nat. Order *Scrophulariaceæ.*—This is only a partial parasite, as it possesses yellowish-green leaves which are able to help in the nutrition of the plant, though much of the food is stolen from a host. Two species are really included under the one name.

(1) *Rhinanthus minor.*—Small yellow rattle, which is very

[1] "Broomrape" (1908), *Jour. Bd. Agric.*, XV, pp. 176-180.

common in pasture land and is parasitic on the roots of grasses and possibly on some other species also.

(2) *Rhinanthus major* (Fig. 29).—Greater yellow rattle, which occasionally makes its appearance in cornfields, where it attacks the cereal crops and does much mischief.

The small yellow rattle is not usually taken much notice of by farmers, but it reduces the crop and turns black in drying, rendering hay in which it is abundant distasteful to animals. The greater yellow rattle is local in this country—the writer has only seen it in part of Wiltshire,[1]—but if it gets a good footing it is capable of depreciating or even ruining the cereal crops.

Unlike dodder and broomrape the yellow rattle develops like a normal plant with an underground branching root system and an aerial stem bearing leaves and flowers. Its roots range themselves alongside the fibrous roots of the host, and at the point of contact suckers are sent out which penetrate to the conducting strands of the host root and absorb nitrogenous food material therefrom (Fig. 30). The attachment is very intimate, and it is impossible to separate host and parasite without breaking the roots badly. Occasionally the suckers appear to penetrate the base of the stem, and in one instance a row of suckers was seen along the outside of the husk of a barley grain. The plant is able to manufacture its own carbohydrate food (as starch and sugar) with the aid of its green leaves and the carbon-dioxide taken in from the air. Large quantities of winged seeds are produced which can retain their vitality in the soil for some years, thus securing the propagation of the plant.

Eradication.—On grass-land yellow rattle is most abundant in fields that are regularly cut for hay, as when once it has gained a footing it has yearly opportunities of ripening quantities of seed. It is less often seen on grazing land, and can be eradicated or at least greatly reduced if constantly mown land is grazed for a number of years, especially if sheep are used. If hay must be taken it should be cut early so as to forestall the ripening of the yellow rattle seeds. The grazing is more effective if it is supplemented by a dressing of basic slag, 7 cwts. per acre, applied before the end of November. In some cases it is useful to apply about 5 to 7 cwts. per acre of salt early in the year, as soon as possible after the seedlings

[1] Brenchley, W. E. (1913), "Yellow Rattle as a Weed on Arable Land," *Jour. Bd. Agric.*, XIX, pp. 1005-1009.

FIG. 29.—YELLOW RATTLE (*Rhinanthus major*), parasitic on Oats.

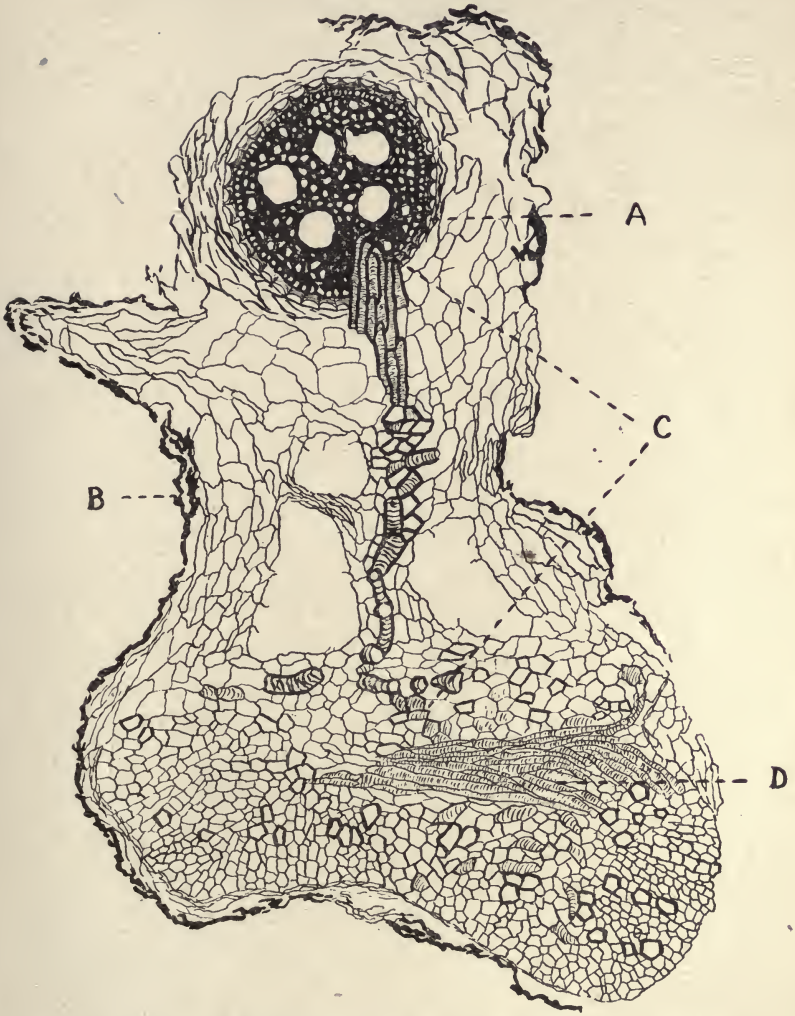


FIG. 30.—SECTION ACROSS BARLEY ROOT PENETRATED BY A SUCKER OF YELLOW RATTLE (*Rhinanthus major*).

A. Root of Barley.
B. Sucker of Yellow Rattle.
C. Cells through which the stolen food passes from the Barley into the Yellow Rattle.
D. Root of Yellow Rattle.

of the parasite appear, as by this means large numbers of the latter are killed. The seedlings may also be destroyed by harrowing in March or even later, but this is not usually as effective as dressing with salt.[1]

Eradication on arable land is a matter of greater difficulty. In ordinary rotation courses cereal crops follow one another at intervals of two years or even less, so that there is no time to work the yellow rattle seeds out of the soil before the favoured host plants are again available. When once the cereals are attacked, mechanical methods of eradication cannot be applied, as the parasites are so closely attached to the hosts that forcible removal of the yellow rattle would injure the roots of the crop. Owing to the infrequency of bad attacks of this weed on arable land little is known as to the best method of cleaning the land; fallowing, coupled with frequent cultivation when the yellow rattle seedlings appear, might do some good. Possibly, too, if the land were grassed over for a time, and grazed by sheep as soon as feed was available, a clearance might be effected after some years. It would be necessary to carry this on long enough to allow most of the seeds to germinate, and then to keep a careful watch when the land was again ploughed up in order to stamp out the pest at its first reappearance.

RED BARTSIA (*Bartsia odontites*) (Fig. 31), Nat. Order *Scrophulariaceæ*.—This partial parasite is rarely accused of causing trouble, but as it is undoubtedly parasitic on the roots of wheat it should be carefully watched wherever it is plentiful. The roots of bartsia attach themselves to the wheat roots in much the same way as in the case of yellow rattle, and part of the food is abstracted from the cereal. Bartsia is obviously half parasitical on the roots of various other plants, as it is often much more abundant on the paths and headlands than it is among the crops. It is seldom present in great quantity, but, if conditions were specially favourable, it might conceivably do some amount of mischief.

Eradication.—No special measures are taken to eradicate this weed, which is usually kept in hand by the ordinary methods of weed destruction.

[1] "The Eradication of Yellow Rattle" (1916?), *Agricultural Department, Univ. Coll. of Wales, Aberystwyth.*

CHAPTER VII.

POISONOUS AND INJURIOUS WEEDS.

THE most obvious damage done by weeds is that to the crops among which they grow, but a certain number of plants work harm by poisoning or otherwise injuring live stock or human beings or by affecting various farm products, for instance milk and wool, in such a way as to depreciate their market value, so causing waste and loss. In some cases it is probable that damage from this cause has been over-estimated, but there is no doubt that it is a point that needs to be borne in mind and guarded against as far as possible. The plants concerned may be considered under two headings :—

(A) Weeds that are harmful to live stock and human beings.

(B) Weeds that injuriously affect farm products.

(A) WEEDS THAT ARE HARMFUL TO LIVE STOCK AND HUMAN BEINGS.

The majority of these are plants possessing some poisonous qualities which either cause death to the animals eating them or else make the stock ill and put them out of condition, financial loss resulting in either case. Exact knowledge on this subject is very difficult to obtain. The reports on suspected plants from various sources are often conflicting, and in most cases hardly anything is known of the true action of the weeds concerned. Also, it is occasionally to the benefit of the unscrupulous to attribute the death of stock to a poisonous weed rather than to its true cause. Ewart [1] sums up the state of affairs as follows: "It is exceedingly difficult or impossible to draw a definite line of demarcation between poisonous and non-poisonous plants. The usual origin of the report as to the poisonous character of a plant is that some stock die, and the nearest plant is selected as the scapegoat,

[1] Ewart, A. J. (1909), "The Weeds, Poison Plants, and Naturalised Aliens of Victoria," p. 11.

without any *post mortem*, experiment, or investigation of any kind. In some cases this is done purposely when the stock have really died from anthrax or similar diseases. On future occasions it is usually easy to find the suspected plant near where the stock have been, and so reports continue to come in. If the plant cannot be found, then some other plant is credited with poisonous properties."

A certain number of weeds, however, are credited with causing harm the world over, and there is little doubt that they are sources of definite injury when they occur to any considerable extent.

In "Plants Poisonous to Live Stock" H. C. Long[1] includes the following farm weeds that have on occasion been found or suspected to be poisonous.

(*a*) *Found Poisonous.*—Autumn crocus, bindweed, bracken, buttercup, charlock, corn cockle, darnel, fool's parsley, hemlock, horsetail, persecaria, poppy, radish, ragwort, scarlet pimpernel, sheep's sorrel, sorrel, spurge (various species), water hemlock or cowbane.

(*b*) *Suspected.*—Broomrape, cat's ear, dodder, ground ivy, mayweed, purging flax, silverweed, sweet clover, tormentil, viper's bugloss, yellow rattle.

Although definite instances of poisoning have been recorded from all the plants in list (*a*) comparatively few of them are so virulent as to need very special precautions with regard to keeping stock out of their way. The worst weeds are more fully noticed in the following paragraphs:—

Bindweed (*Convolvulus arvensis*).—This is seldom considered to be harmful, but the underground stems are purgative and the seeds are poisonous to stock if eaten in any quantity.[2] If the seeds are ground up in flour they are said to render it injurious to health, besides making it a bad colour.

Buttercup (*Ranunculus sp.*).—Opinions differ as to the harmfulness of the various species of buttercup, but many of them contain an intensely acrid juice which under some conditions, at least, may cause poisoning when the plants are eaten by animals. Henslow[3] states that if too many buttercups are eaten they may cause death, but that as drying dissipates the deleterious principle horses and cows may then eat them with-

[1] Long, H. C. (1917), "Plants Poisonous to Live Stock," Cambridge Agricultural Monographs, Cambridge University Press.

[2] Ewart, A. J. (1909), *loc. cit.*, p. 48.

[3] Henslow, G. (1901), "Poisonous Plants in Field and Garden," p. 37.

out any injurious results. As a matter of fact, buttercups being usually most plentiful in luscious pastures where plenty of more appetising food is available the cattle thrust them aside and do not eat sufficient to harm themselves. The degree of toxicity varies with the stage of growth, as the young shoots in the spring are almost harmless in most species, but the amount of the poisonous substance increases as time goes on, often reaching a maximum at the time of flowering, the blossoms being more poisonous than other parts of the plants.

Corn cockle (*Lychnis githago*). — The damage wrought by this weed is very generally recognised, both with regard to its effect on stock and on human beings. As so often happens the reports as to its toxicity are very varied, but the consensus of opinion brands corn cockle as productive of much harm. The whole plant is more or less poisonous, but the seeds are by far the most dangerous and most of the trouble arises when they are eaten. As they are much the same size as wheat grains they are difficult to separate out, and when they are ground up they give the flour an unpleasant greyish colour, and, if sufficiently plentiful, render the bread injurious to health. The poisonous principle, githagin, is not supposed to be destroyed by baking,[1] or, even if partially decomposed, sufficient remains unchanged to make the bread harmful,[2] and fatal results have followed the use of it.[3]

Animals vary in their response to the action of corn cockle, but from the various experiments quoted by Long it is apparent that calves, pigs, and horses are very susceptible, and that on the whole young animals are more harmed than older ones. It is less certain how far birds and poultry are affected, but Hungarian experiments[4] have shown that geese died when fed with meal containing 40 to 50 per cent. of corn cockle seeds, even when this meal was added to other food. Degen also states that corn cockle can produce grave symptoms of poisoning in poultry, the pathological symptoms closely resembling those of acute mineral poisoning.

The weed is sometimes plentiful in wheat crops, but as

[1] Henslow, G. (1901), *loc. cit.*, p. 60.

[2] "Some Weeds of Iowa" (1903), *Experiment Station, Iowa State College, Bull.* 70.

[3] Long, H. C. (1917), *loc. cit.*, pp. 19-22.

[4] Degen, A. (1916), *Kiserletügyi Kozlemenyek*, XIX, Part I, pp. 11-21. See *Internat. Review of Sci. and Pract. of Agric.* (1916), VII, pp. 1629-1630.

it is a very conspicuous plant it can be removed by hoeing or handpulling before the seeds ripen.[1]

Fool's parsley (*Æthusa cynapium*).—A considerable difference of opinion exists as to the toxic nature of this weed, but there can be little doubt that it is decidedly poisonous. Stock seem to refuse it and so rarely suffer by it, but humans have been poisoned by using the leaves in mistake for parsley. In some cases the consumption of the plant causes active poisoning, in others it is said to be harmless ; it is possible that this contradiction may be due to the fact that the toxic principle or alkaloid (coniine) varies in quantity according to the conditions of climate and habitat under which the plant is grown, or according to the stage of development in which the weed is eaten.[2] Barthe [3] includes fool's parsley among the poisonous Umbelliferæ.

Hemlock (*Conium maculatum*).—This plant has long been famed for its poisonous qualities and is supposed to be the source of the decoction drunk by Socrates. It is strongly narcotic and causes paralysis and death. Probably hemlock has caused more harm to human beings than to farm animals, as the leaves have been mistaken for parsley, the roots for parsnips, and the seeds have been used in error for anise.[4] Usually stock avoid it because of its strong fœtid odour, which is especially marked when the plant is bruised. Goats seem to be largely immune from the action of the poison,[5] which is most abundant in the seeds but is also present in the stem and leaves. The reports of the toxicity of hemlock vary from different places, but according to Barthe [6] this increases as one passes from cold to warm climates, and he states that in North Europe it can be eaten without ill effects. Whenever possible the plants should be pulled up and burnt and the ground kept covered with other vegetation to prevent re-establishment by seedlings. The seeds are said to be very short-lived and in this way lose their vitality without the opportunity of germinating.

Horsetail (*Equisetum spp.*).—Field horsetail (*Equisetum arvense*) is the species usually met with on farms, but others

[1] A general description and discussion of the poisonous qualities of corn cockle is given in *Jour. Bd. Agric.* (1910), XVII, pp. 38-45.
[2] Long, H. C. (1917), *loc. cit.*, pp. 39-40.
[3] Barthe, L. (1918), " Toxicologie chimique," p. 499.
[4] Long, H. C. (1917), *loc. cit.*, p. 41-42.
[5] Ewart, A. J. (1909), *loc. cit.*, p. 29.
[6] Barthe, L. (1918), *loc. cit.*, p. 499.

occur as well, and this may account for the conflicting opinions as to the poisonous nature of the weed. There can be no doubt, however, that some species of *Equisetum* are actively injurious to stock, and *Equisetum arvense* is probably one of them. German feeding experiments have indicated that field horsetail (*E. arvense*) is harmless to the larger domesticated animals, while the marsh horsetail (*E. palustre*) is really injurious to cattle. In America, on the contrary, it is stated that *E. arvense* has proved fatal to horses, especially young animals.[1] Complaints of *Equisetum* poisoning are fairly frequent in the Russian Agricultural Press, horses and cattle suffering more from the effects of eating the plant dried (in hay) than green.[2] In feeding experiments dried *Equisetum arvense* was mixed with hay, the quantity being gradually increased from ½ to 6 lb. per day. At first the animals preferred it to the rest of their food, but gradually left it alone, and after fourteen days would hardly touch it. At the end of this time symptoms of poisoning were evident, and it was concluded that the weed, to be dangerous to horses, must be present in large quantities, but might then prove fatal.[3] This is corroborated from Canada, as Howitt [4] states that if fed in quantity in hay *E. arvense* is poisonous to horses. In some parts of England, as at Chedzoy, on Sedgemoor, horsetail has a very bad reputation for causing scour in cattle, but horses and sheep are said to be unaffected by it. As various species are classed under the popular name it is probable that some cause scouring and others do not, which may account for the indifference with which the plant is regarded by farmers in some places and the objection to it in others. Cattle dislike the weed and eat round the clumps in order to avoid it as far as possible.[5]

The presence of *Equisetum* indicates poor drainage, and if this is attended to by deep ploughing on arable land, and by underdraining grass-land, in addition to keeping the water courses clear, it is not usually difficult to eradicate the weed.

Meadow saffron or autumn crocus (*Colchicum autumnale*)

[1] See Long, H. C. (1917), *loc. cit.*, pp. 84-85, for a fuller account of this work.

[2] *Trudy Bjuro po prikladnoj Botanikje*, Jan., 1916; see *Jour. Bd. Agric.*, XXIII, p. 278.

[3] "Horse Poisoning by *Equisetum arvense*" (1912), *Kew Bull. Misc. Inform.*, No. 3; see *Jour. Bd. Agric.*, XIX, p. 229.

[4] Howitt, J. E. (1916), "Weeds of Ontario," *Ontario Dept. of Agric.*, p. 22.

[5] Brenchley, W. E. (1916-17), "West Country Grass-lands," *Jour. Bath and West and Southern Counties Soc.*, XI, p. 97.

(Fig. 32).—This plant is local, but very abundant when it occurs, and is one of the most poisonous of our British farm weeds, numerous cases of loss of stock having been traced to it. In Switzerland [1] cases of poisoning of household animals and human beings are recorded every year. Horses are poisoned by the green plant or by dried leaves in hay. Cattle usually avoid it in any form, though young animals are frequently poisoned. Poisoning often occurs in the spring when beasts fed in the stall during the winter are let out on the young grass. Pigs are affected, but sheep and goats seem to be more or less immune. The flowers appear alone in the autumn, no leaves being then produced, and the seed vessel remains below the soil. After the flowers die down no more is seen of the plant till the following spring, when leaves appear and the seed vessel rises out of the ground. Every part of the plant is poisonous, corm, leaves, flowers, and seeds, so that danger to stock occurs both in autumn and spring. Occasionally, if the spring is late, the leaves may appear in hay and so cause trouble, but generally it is grazing stock that are liable to be affected. Grazing is safe enough in the summer and winter while the plant is resting, but during the spring and autumn stock should be rigidly excluded from fields containing the weed. The toxic principle, colchicine, is not volatile and is not removed by drying the plants, so that the leaves are as harmful in hay as when fresh, and as the poison seems to be cumulative repeated small doses may eventually cause poisoning.[2] Warm milk has been recommended as an antidote. With perseverance meadow saffron can be easily eradicated ; seeding may be prevented by dragging a crossbeam with bundles of brushwood and bushes attached, over the meadow when the plants are flowering, thus destroying the blossoms,[3] while the corms can be weakened and starved out by cutting and handpulling the leaves in spring. A special digging iron for the destruction of the corms has also been employed.

Purging flax (*Linum catharticum*) (Fig. 33).—This is regarded as a suspected plant only by Long, but it has often been known to occur in meadows or in hay which has caused

[1] Stebler and Schroeter, *Matten und Weiden der Schweiz*, IX, p. 209, Summ. in *Jour. Bd. Agric.* (1908), XV, p. 303.

[2] (1908), "Meadow Saffron," *Jour. Bd. Agric.*, XV, pp. 44-45.

[3] (*a*) *Illustrierte Landwirtschaftliche Zeitung*, No. 27 (1912), (*b*) Bornemann, "Die wichtigsten landwirtschaftlichen Unkräuter," p. 68 (see *Jour. Bd. Agric.* (1913), XIX, p. 852).

purging or death to the animals fed thereon. Under some conditions prussic acid is developed by the plant and this would

FIG. 32. — AUTUMN CROCUS (*Colchicum autumnale*).

FIG. 33.—PURGING FLAX (*Linum catharticum*).

be quite sufficient to cause the results recorded; therefore it is wiser to regard with suspicion pastures or meadows containing this flax.

Ragwort (*Senecio jacobæa*).—The harmful nature of this

weed is not often recognised in England, probably because the first symptoms of poisoning are so insidious, but the Board of Agriculture has called attention to the fact as the danger of loss is considerable.[1] In Australia,[2] New Zealand, and Canada,[3] however, ragwort is considered a very bad weed as it induces a fatal disease, cirrhosis of the liver. The symptoms only appear after one to three months continuous grazing on the plant, and even if the cattle are removed while they still appear healthy, after-symptoms may manifest themselves, leading to fatal results. Horses and cattle suffer badly, but it is uncertain whether sheep are affected. Probably the plant is most actively poisonous in June, July, and August, and as there is no known cure it is essential that ragwort should be eradicated from pasture land and not allowed to enter into hay. This can be done (1) by grazing with sheep in winter or early spring before much growth has been made, (2) by cutting the plants in the flowering stage, the cut portions being gathered up and burned, (3) by handpulling early in July. The plant being biennial eradication must be carried on for two years, and watch must also be kept against fresh infestation by seeds carried by the wind.

Shepherd's purse (*Capsella bursa-pastoris*).—This is rarely considered to be poisonous, but a case is on record in which two children were poisoned by eating the tops of the plants,[4] their lives being saved with difficulty. This does not necessarily imply that shepherd's purse is poisonous in the ordinary way, as certain individuals are often adversely affected or poisoned by foods that are harmless to most people, e.g. some people are unable to eat strawberries without suffering from a type of poisoning.

Water hemlock or cowbane (*Cicuta virosa*).—This is not in reality an arable or grass-land weed, but as it is exceedingly poisonous and may be found in damp areas or water courses to which stock can gain access, it must not be left out of consideration. Happily it is not very common or abundant in this country, but in other parts of the world it flourishes and special precautions have to be taken against it. The greater part of the poisonous principle is present in the rhizomes or

[1] "Poisoning of Cattle by Ragwort" (1917), *Jour. Bd. Agric.*, XXIV, pp. 433-436.
[2] Ewart, A. J. (1909), *loc. cit.*, p. 42.
[3] Howitt, J. E. (1916), *loc. cit.*, p. 95.
[4] Kellerman, W. A. (1895), "Poisoning by Shepherd's Purse," *Bot. Gaz.*, XX, pp. 325-326.

underground stems, and possibly these are the only parts of the plant that are actually poisonous as it is said that the stems and leaves can be eaten in quantity with impunity.[1] The poison is very rapid in its action, the first symptoms appearing in about twenty or forty minutes, and death resulting if a fatal dose has been swallowed. Wherever water hemlock is known to occur the plants should be grubbed out and burned; great care being taken not to leave any portions of the rhizomes lying about where animals can get them. The pulled plants should not be left in the water as the toxic principle, cicutin, dissolves out and contaminates it, thus giving rise to another source of trouble.[2]

In addition to the above outstanding weeds there are a few which are certainly poisonous or otherwise harmful, but which are only locally or occasionally present in sufficient quantity to cause trouble.

Sheep's sorrel (*Rumex acetosella*) is charged [3] with having poisoned a horse and sheep which browsed upon it when the fruit was ripe and full of seeds, with fatal results to the horse. The nature of the poisonous principle, if any, is not known, unless the toxic action was due to the acid oxalates that are present in the plants. Spurges (*Euphorbia spp.*) are usually avoided by stock, but if eaten are harmful as the juice is acrid and the seeds contain an extremely purgative oil. Stagger weed (*Stachys arvensis*) seldom occurs in any quantity in England, but in the Dominions it is reported as causing serious trouble among cattle.[4] It is a weed of damp places and may be eradicated by draining. Black nightshade (*Solanum nigrum*) sometimes does mischief, and Barthe states that it is poisonous in warm and temperate regions, but loses its poisonous properties in the cold northern regions.[5]

Without being actually poisonous some weeds may cause trouble if they are eaten or handled. Broomrape (*Orobanche minor*) has been found to produce colic in animals fed on clover, in which it grows plentifully, while the seeds of black bindweed (*Polygonum convolvulus*) may, after some time, cause

[1] Fleming, C. E. (1918), "Range Plants Poisonous to Sheep and Cattle in Nevada," *Agric. Exp. Stat., Univ. of Nevada, Bull.* No. 95, p. 23.

[2] Smith, J. D. (1917), "Weeds of Alberta," *Bull.* No. 2, *Province of Alberta, Depart. of Agric., Seed and Weed Branch*, p. 98.

[3] Henslow, G. (1901), *loc. cit.*, p. 142.

[4] Maiden, J. H. (1916), "Asphodelus fistulosus and Stachys arvensis: Harmful Weeds in New South Wales," *Agric. Gaz., New South Wales*, XXVIII, pp. 335-338.

[5] Barthe, L. (1918), "Toxicologie chimique," p. 518.

serious internal derangements if too many are present in the oats fed to stock.[1] In Belgium, hogweed (*Heracleum sphondylium*) is supposed to have caused "Panaisie," a kind of erysipelas induced if the plants are rooted up when they are covered with dew. No harm results when hogweed is pulled later in the day,[2] because then the dew, in which it is suggested that an irritant essential oil is dissolved, has been dissipated by the sun.

Occasionally mechanical injury is caused by local irritation due to very rough or sharp weeds or by the accumulation of indigestible masses in the alimentary canal. Huffcaps (*Aira cæspitosa*) is an exceedingly coarse and rough grass and rasps the mouth badly, and in places where it occurs a clause is inserted in many leases to the effect that the land must be kept clear of it by cutting or otherwise.[3] The sharp awns of certain grasses, as wild barley and brome, tend to penetrate the gum and break off, giving rise to considerable inflammation, and if the heads are swallowed they may accumulate or "ball" in the stomach of the animal. The fibres of shepherd's purse and the much branched chickweed are liable to cause trouble in the same way if they are eaten too freely.

(B) Weeds that Injuriously Affect Farm Products.

The milk of cows and the flesh of stock is liable to become tainted if any strong smelling or strong tasting plant is included in the animals' food, and many complaints of unpleasant flavours have been traced to this source. There are not a large number of weeds that are proved to taint farm products, but some of these have been in bad repute from early days. In 1789 Adam[4] included dyer's weed (*Reseda sp.*), darnel (*Lolium temulentum*), cow-wheat (*Melampyrum sp.*), melilot (*Melilotus sp.*), and crow garlic among the weeds that spoil farm products, and most of these had been known for long before.

Crow garlic (*Allium vineale*) (Fig. 34) and ramsons (*A. ursinum*) (Fig. 35) bear the worst reputation for tainting milk and for injuring wheat and flour. Crow garlic is difficult to distinguish among grass until it flowers, as the leaves are very narrow, so that suspected pastures should be very carefully examined before stock is turned in in the spring. Although

[1] Henslow, G. (1901), *loc. cit.*, p. 141. [2] *Ibid.*, pp. 99-100.
[3] Brenchley, W. E. (1916-17), "West Country Grass-lands," *ibid.*, p. 97.
[4] Adam, J. (1789), "Of Weeds," "Practical Essays in Agriculture," II, pp. 173-198.

the tainting of milk and butter is universally admitted, opinions differ as to how the mischief is worked. Some people hold that

FIG. 34. — CROW GARLIC (*Allium vineale*), showing underground bulb with bud and cluster of aerial bulbils on the flowering stalk.

FIG. 35.—RAMSONS (*Allium ursinum*).

it is entirely due to dirty milking, whereby small pieces of garlic leaves fall into the pail, but that this is the explanation is improbable in the majority of cases. Some farmers hold that garlic taints the breath of cows, as it does that of man, and that

in some way or other this influences the milk, but this again is highly improbable. It is far more likely that the direct taint is imparted to the milk in some physiological manner not well understood, and possibly the taint is carried in the fat globules more readily than in the rest of the milk. One dairy farmer known to the author has fed cows on "garlic wheat" or even on "garlic with wheat in it" and had no suspicion of trouble nor complaints of the milk being tainted. In American experiments[1] it has been found that increasing the length of time between feeding on the onion and the hour of milking reduced the unpleasant odour and flavour. There is only a slight odour and flavour in milk when cows are kept off onion infested pastures for four hours before milking and this slight flavour is said to disappear almost entirely when the milk stands for four hours. Even if this be so it is wiser to keep milking cows out of fields known to be infested with garlic during the growing period of the plant in spring and early summer. There is an idea among graziers that store beasts and cattle may safely be run in these fields, the garlic often acting as a mild tonic or aperient, but that fattening sheep and cattle should be kept away lest their flesh become tainted.

Crow garlic is occasionally a pest on arable land, and as the aerial bulblets are about the same size as wheat grains it is difficult to separate the two, and the value of the wheat is thereby depreciated. Bread made from garlicky flour, especially if eaten warm, has a pronounced odour and flavour, and in the United States it is estimated that the money loss from wild onion runs into millions of dollars yearly.[2]

Ramsons is closely allied to the crow garlic and sometimes causes similar trouble. It is readily distinguished by its thin, flat spreading leaves, and when it is abundant in the shady places it prefers the milk of cows that gain access to it becomes badly tainted, and it is said that the flavour is strongly accentuated if the milk is scalded.

Darnel (*Lolium temulentum*) is possibly the "tares" of Scripture, and its harmful nature has been known for centuries. It sometimes grows freely among wheat; the seed being nearly as large as wheat it is difficult to separate the two, with the result that the darnel discolours the flour and gives a disagreeable taste to the bread. Under some circumstances the

[1] Cox, H. R. (1918), "Wild Onion, Method of Eradication," p. 11, *U.S.A., Depart. of Agric., Farmer's Bull.* 610.

[2] *Ibid.*, p. 3.

weed is not merely unpleasant but dangerous, and cases of human and stock poisoning have been known to occur. Adam[1] states that the seeds possess a very intoxicating quality and bring on convulsions if taken in large quantities, and in France darnel is called Ivraie because when brewed with barley it acts as a narcotic intoxicant.[2]

Melilot (*Melilotus spp.*) occasionally occurs as a weed in this country, though in America and elsewhere it is grown for fodder. Ewart[3] states that the sweet smelling cumarin, which all the species contain, in excess produces a disinclination to locomotion, paralysis and ultimately fatal symptoms, but that no harm is likely to occur if the amount of melilot present does not exceed 10 per cent. of the herbage. According to Adam,[4] if the seeds are ground with the corn they spoil the flour, as the bread made from it has a strong taste and smells like melilot plaister.

Pennycress or stinkweed (*Thlaspi arvense*).—Complaints of this weed are not often heard in this country, because it seldom happens that it is abundant enough to work harm, but in the Dominions it is regarded as most noxious and special measures are adopted against it. The whole plant has a peculiarly objectionable odour, somewhat resembling that of garlic, and the seed is very pungent. The stinkweed taints milk and butter and also the flesh of animals that eat it, causing considerable loss where the weed is plentiful.[5]

Various other weeds are accused of tainting milk and butter, but the evidence in many cases is less clear, and possibly local conditions of soil and climate may make a species harmful in some cases and innocuous in others. Among the accused weeds are buttercups, wild mustard and charlock,[6] yarrow, dog daisy, chamomile and mayweed,[7] while woodwax (*Genista tinctoria*) is supposed to make milk bitter.

The hooked fruits or burs of various weeds when abundant are another source of loss to the farmer. These burs stick to the wool of sheep as the animals rub against them, and it is impossible to extricate them from the fleeces without

[1] Adam, J. (1789), *loc. cit.*, p. 188.
[2] Long, H. C. (1917), *loc. cit.*, p. 83.
[3] Ewart, A. J. (1909), *loc. cit.*, p. 23.
[4] Adam, J. (1789), *loc. cit.*, p. 192.
[5] Henderson, T. B. R. (1909), "Stinkweed, How to Hold it in Check," *Press Bull.* No. 2, *Province of Alberta, Depart. of Agric.*
[6] F. M. (1910), "Crucifers and Milk," *Revue Scientifique*, p. 599.
[7] Long, H. C. (1917), *loc. cit.*, p. 101.

wasting a considerable amount of wool. Cleavers, corn buttercup, geum, agrimony, and other plants that depend upon animals for their distribution all contribute to this loss, and where sheep are kept it is very important that special care should be taken in the eradication of this type of weed.

CHAPTER VIII.

ARABLE WEEDS. ASSOCIATION WITH SOILS.

I. General.

In travelling about the country and inspecting fields in various districts the first impression received is that the individuals of the weed flora are very closely determined by the type of soil on which they grow. Sandy land is often smothered with poppies, spurry or corn marigold, boggy soil is carpeted with willowweed, chalk shows abundance of chicory, and loam and clay present a general mixture of weeds without any great outstanding species. A closer investigation shows that this first impression is to a large extent erroneous, that most individual species of weeds may be found on different kinds of soils in various parts of the country and that comparatively few weeds are definitely associated with any particular soil. Still closer examination of the weed populations shows that as a general rule the weed communities are far more characteristic of the different soils than are the individual species. The communities vary within themselves in different localities, but in their broad outlines they show some connection with the character of the soil. It is probable that many factors interact to determine the nature of the weed population, and that the mere chemical or mechanical composition of the soil is of comparatively little importance except in so far as it is bound up with other factors such as drainage, rainfall, temperature, season, acidity, and aeration. The interaction of all these factors determines the relative competition of the species growing on the soils, and so the personnel of the weed communities is profoundly affected. The influence of factors other than soil is often well shown by the difference in the proportions between the weeds that grow in wet seasons and dry seasons. If the season be very wet some plants gain the upper hand at an early date and maintain their position all through the year, whereas if the season be dry quite another set of plants comes to the front on the same soil.

The whole question of weed population probably resolves itself into one of competition between the different species. The absence of a weed in any particular situation may be due to one of several reasons:—

(1) The plant is so unsuited to the soil that it will not flourish on it under any circumstances.

(2) Other species are so much more favoured by the conditions of growth that the particular species concerned is smothered out and is unable to make any headway.

(3) The method of cultivation may be such as to hinder the species from establishing itself.

(1) It very frequently happens that a species is absent from a particular type of soil in one place while it is present or even abundant upon similar soil in other districts. The conclusion may be drawn that comparatively few plants are really antipathetic to any soil, and that if other conditions are suitable most plants will grow, at least to some extent, on any kind of soil. Naturally, there are exceptions to this rule, but they are probably less frequent than they seem at first sight. Salt marshes are characterised by a specialised set of plants adapted to the peculiar conditions induced by the flooding with salt water which occurs at high tides. These species, as *Salicornia* spp., *Suæda maritima* and *S. fruticosa*, *Aster tripolium*, *Glaux maritima* and several others are never found as weeds of cultivation or in any inland area. Nevertheless it is quite possible to grow them in ordinary soil and to obtain good plants. On the other hand, the salt marsh conditions are so exceedingly abnormal that the majority of land plants find it impossible to live in such situations, because the combination of waterlogging, flooding, and an excess of salt render the position untenable. But, as soon as the land is drained and the floods are kept back by dykes the typical land plants soon find entrance and before long oust the original occupants of the soil.

Sorrel and sheep's sorrel are usually associated with acid soil, and it is sometimes asserted that they will not grow in the presence of a sufficient supply of lime. Rothamsted experiments have shown that, *in the absence of competition of other plants*, these species do better with a full supply of lime than they do on an acid soil. Pot cultures were carried on with a light soil, deficient in lime. The amount of chalk necessary to correct the acidity of the soil was determined and then calcium carbonate was added to the pots in varying

proportion so that a series was obtained containing $\frac{1}{4}$, $\frac{1}{2}$, $\frac{3}{4}$, 1 and twice the amount of chalk really required. Various seeds were sown, including grasses, *Rumex acetosa*, *R. acetosella*, and *Trifolium pratense*, and in addition a mixture of all the seeds was made and sown in big pots prepared with soil similar to that in the small pots. The plants were all kept under the same conditions in a glass house and were carefully watered. At the close of the experiment the plants were cut, weighed green, dried thoroughly and weighed again. It was found that by far the heaviest crop of *Rumex acetosa* was obtained from the pots that received twice as much chalk as was needed, and that the weight of the crop was rather less in the more acid soils than in those pots which had received a complete dressing of chalk, thus disproving the statement that sorrel prefers an acid soil to one containing a sufficiency of lime.

Rumex acetosa.

Lime Requirement (Supplied as Chalk).	0	$\frac{1}{4}$	$\frac{1}{2}$	$\frac{3}{4}$	1	2
	gms.	gms.	gms.	gms.	gms.	gms.
Average green weight per pot .	10·85	9·7	11·5	12·9	12·5	21·0
Average dry weight per pot .	2·1	1·75	2·17	2·1	2·43	3·8

The sheep's sorrel germinated very badly in all the pots and only one or two plants grew at all. The only pots in which any fair amount of growth was made were two which had received $\frac{3}{4}$ and a full supply of lime, thus again showing that this species will grow well on soils which are not acid.

All the other species grown alone made satisfactory growth in the soils of varying acidity, as, owing to the absence of competition, they were able to make the most of the soil even though it were not really very congenial. In the big pots, on the other hand, the proportions of the various species varied with the acidity, indicating that directly competition came into play the plants that were most favoured by their particular soil gained the upper hand, while the species that were more indifferent suffered by the crowding of the other plants and consequently developed less strongly.

The explanation of the discrepancy between the results of these pot cultures and the ordinary field observations probably lies in the mere fact of the varying conditions of competition between the plants. Acid conditions of soil are not particularly

favourable to the growth of most species, but *Rumex acetosella* is quite indifferent to them. Consequently, while most plants are hesitating to start boldly into growth the sheep's sorrel pushes ahead, dominates the situation from the first and holds its own to such an extent that many of the other weeds do not have a fair chance to make a start. On ordinary soils, however, the competition is keen from the beginning. Sheep's sorrel would be quite content with the soil conditions, but it cannot put up with the competition of other species, and consequently it gets crowded out of existence. This does not, of course, imply that if competition were removed sheep's sorrel would spring up everywhere, as seeds would not be present in every soil. In the general distribution of species the balance has been continually adjusted, until now a few species are very specially associated with particular soils while the great majority of plants will grow everywhere if conditions are favourable. Thus the struggle for existence is continually going on and the balance of dominating species is shifting day by day in response to the perpetual changing of the conditions which favour or inhibit growth.

This being the case, very few, if any, arable weeds can be regarded as symptomatic of the soil on which they grow—i.e. there are practically no individual species which indicate infallibly the nature of the land where they occur. Individual species are therefore of little use as decisive indicators, but communities of species give much more accurate information. For instance, the presence of sheep's sorrel indicates acidity of soil, though it does not necessarily show whether the land is heavy or light, but if it is associated with spurry and annual knawel the community or association of species shows definitely that the soil is very light or sandy in addition to being acid. Again, though no single weed is exclusively associated with clay land, the presence of such a mixture of weeds as black bent, hoary plantain, corn buttercup, coltsfoot, and couch-grass at once indicates a heavy soil. In considering the association of weeds with soil, therefore, it is necessary to lay more stress on the particular communities in which the plants occur than on the connection of one particular species with one definite type of land.

CHAPTER IX.

ARABLE WEEDS. ASSOCIATION WITH SOILS.

II. Special.

In order to get some definite idea of the association of weeds with crops and soils from the statistical point of view weed surveys have been carried on for several years in different parts of the country. In the course of the investigations many hundreds of fields have been visited, the crops and the nature of the soil observed, and detailed notes made of every weed occurring on each field with its relative abundance or scarcity. The results thus obtained[1] have been carefully analysed and compared, and have provided the figures on which are based the observations made in the present chapter. The weed survey is preliminary and incomplete as it only deals with a limited number of districts, and the conclusions put forward may be subject to modification when more data become available from other parts of the country. The variety of soils, however, is considerable, the areas worked were far apart (ranging from Somerset to Norfolk), and the correspondence in the results from the different districts is sufficiently close to justify the belief that later modifications will be matters of detail rather than of principle.

In considering the association of particular weeds with special types of soil the remarks made in the previous chapter should always be borne in mind. A plant may be more or less characteristic of a certain soil when it occurs in any quantity, and yet it may be present on every other type of

[1] Brenchley, W. E. (1911), "The Weeds of Arable Land in Relation to the Soils on which they Grow," I (Bedfordshire), *Ann. Bot.*, XXV, pp. 155-165.
(1912) *Ibid.*, II (Wiltshire and Somerset), *Ann. Bot.*, XXVI, pp. 95-109.
(1913) *Ibid.*, III (Norfolk), *Ann. Bot.*, XXVII, pp. 141-166.
(1915) "Weeds on Arable Land and their Suppression" (Nottinghamshire and Derbyshire), *Jour. Roy. Agric. Soc.*, Vol. 76, pp. 14-37.
(1916-17) "West Country Grass-lands," *Jour. Bath and West and Southern Counties Society*, XI, pp. 85-112.

soil to some extent, or it may be absent in one district from the very soil on which it is so characteristic elsewhere. Consequently exceptions will be found to nearly every statement made, and it is only by gathering together and correlating evidence from many sources that any approach to real accuracy will be made.

For purposes of convenience soils may be classified as follows :—

(1) Clays and heavy loams.
(2) Medium loams.
(3) Light loams and sand.
(4) Chalk.
(5) Special soils, as peat.

Such a classification is necessary for working purposes, but in actual fact no hard and fast line can be drawn between the different sections. Clays and heavy loams merge imperceptibly into the medium soils,and there is no sharp dividing line between medium loam and the lighter soils. Again, land that is termed clay in one part of the country will pass as loam elsewhere, the terminology depending to a large extent upon the general nature of the soils in the surrounding district. Nevertheless, when an investigator is constantly working on various soils in different districts, a recognition of the relative lightness or heaviness of the land develops almost instinctively, and experience enables the classification of the weeds according to the soil they occupy to be made with a fair degree of accuracy.

In addition to determining the soil with which a weed is associated, it is necessary to draw a distinction between the frequency with which a plant occurs and the amount of it that is present. A weed like field forget-me-not may be frequently found on any soil, and yet it may occur in such small quantities that it is often noted as being scarce in the fields, while it may never be present in such abundance as to be dominant.[1] On the other hand, such plants as field speedwell,

[1] The relative abundance of weed species in any field is indicated by the following terms :—

(1) *Dominant.*—When one species is much more abundant than any other.

(2) *Sub-dominant.*—When a second species, less plentiful than the dominant one, is also more plentiful than the other species of the flora.

(3) *Distributed.*—When a weed is rather plentiful over the whole of a field, but is not relatively more abundant than other associated species.

(4) *Occasional* or *sparse.*—When occasional specimens of a weed are to be found here and there.

(5) *Scarce* or *rare.*—When isolated individuals occur, sometimes only one or two specimens being found.

chickweed, curled dock, and fat hen are found on all soils in such abundance that they are often dominant. Again, a weed may occur on all soils but it may be far more abundant on some types than on others, as happens with ribwort plantain which is occasionally dominant on chalky soils and not elsewhere, and black bindweed which is often dominant on light soils but not on heavier land. This local dominance of ubiquitous weeds gives a good indication of the soils which are really preferred by the species. Thus the frequency with which a weed occurs is not necessarily associated with its abundance. Naturally enough the weeds that are of universal distribution are usually the most frequent in occurrence, as they are not limited by the soil conditions, and so have a greater choice of habitat, but on the other hand plants that are specially localised, as spurry and white mustard, are generally far more abundant in their particular situation than are the weeds of general distribution.

In the following pages a weed is said to—

(1) be *characteristic* of a soil when it is usually frequent or abundant on that soil but only occurs infrequently and in small amounts on other types of land.

(2) have a *preference* for a particular soil if it is more often frequent or abundant on that soil than on any other.

(3) be *generally distributed* if it shows no preference for one soil more than another.

The chief arable weeds may be classified according to their association with soils, as follows:—

A. *Weeds of General Occurrence.*

- (*a*) Plants that are equally distributed on all types of soil.
- (*b*) Plants occurring on all soils, but less frequently on heavy land.
- (*c*) Plants occurring on all soils, but less frequently on chalk.

B. *Weeds Specially Associated with Heavy Land.*

- (*a*) Plants characteristic of heavy land (clay and heavy loam).
- (*b*) Plants common on heavy land, but also of general distribution.
  - (1) Plants which flourish equally well on chalk.
  - (2) Plants which do not occur so frequently on chalk.
    - (*α*) With distinct preference for the heavier soils.
    - (*β*) Equally plentiful on heavy and medium soils.

C. *Weeds Characteristic of Sand and very Light Soil Deficient in Lime.*

D. *Weeds Associated with Chalk.*

(*a*) Plants characteristic of chalk.

(*b*) Plants with a definite preference for chalk, but also occurring on all soils.

(*c*) Plants with a definite preference for light and sandy soils as well as for chalk.

E. *Weeds Associated with Peat Soils.*

A. *Weeds of General Occurrence.*

By far the larger proportion of arable weeds are to be found distributed over all types of soil instead of being definitely associated with one or two particular soils. At first sight it looks as though these weeds were absolutely indifferent to the nature of their habitat, but a close numerical analysis of observations made on their occurrence shows that there is a considerable amount of differentiation, and that even though a weed be of universal distribution it often has definite preferences or mild dislikes for certain soils. This is shown both by the frequency with which a weed occurs on a soil and by its relative abundance, and the weed communities which are characteristic of the different habitats owe a great deal to those plants that are very tolerant and that yet have their preferences as to soil. The presence of a quantity of the universally distributed scabious (*S. arvensis*) on chalky land is quite as characteristic as that of wild mignonette (*Reseda lutea*), which is practically confined to such situations. Indeed, there are so few plants which are really soil indicators that if it were not for the grouping into characteristic communities of these weeds of general distribution it would be difficult or impossible to determine the weed communities that are associated with the different soils.

It is gradually becoming evident, however, that much of the "universal occurrence" of certain weeds is more apparent than real. Some of the commonest weeds, as knotgrass (*P. aviculare*), show very great difference in character—differences so great that it seems impossible that they are due to mere local variations brought about by particular conditions of soil and climate. The knotgrass will vary from a type consisting of very thin, wiry stems bearing tiny narrow leaves hardly $\frac{1}{4}$ inch long to another of a much more succulent nature, in some cases with

large broad leaves nearly 2 inches long. It is an accepted fact that many of these variations constitute true sub-species, but the classification and differentiation are still so hazy and uncertain that it has not yet been practicable to make use of these "splits" of species in studying the weed flora. It is, however, very probable that when matters are cleared up more it will be found that some of the main splits are of very great importance and possibly certain splits will prove to be as characteristic of different types of soil as such species as spurry are of sand. Meanwhile we must be content to accept these weeds as occurring on all soils, remembering that we may be dealing with a variety of types instead of with a single one.

The account of the weeds of general occurrence may conveniently be broken up into sections according to the classes of soils that are more or less particularly favoured. The division is made with due reserve, and is purely artificial in nature, because its truth and convincingness will vary according to the districts, soils, and cultural conditions with which the reader is acquainted. Weeds that are classified into one section on a general analysis may belong to another section for a particular area, so it must be borne in mind that the classification is the result of observations made on many hundreds of fields scattered over the country, and so may give a fairly true general picture.

(*a*) *Plants that are Equally Distributed on all Types of Soil.*—A certain number of weeds appear to be truly ubiquitous, occurring on any and every soil without preference. Naturally enough some of the very commonest farm pests come under this heading, as the faculty of being able to live happily under any circumstances favours the spread and persistence of these plants to an exceptional degree. Some of them are very widely spread, as is shown by the following table which gives the number of times some of the commonest weeds were noted during the investigation, together with their percentage of frequency [1] on the various classes of soils :—

[1] Percentage of frequency = number of times seen per 100 fields.

TABLE I.—WEEDS OF GENERAL OCCURRENCE, EQUALLY DISTRIBUTED ON ALL TYPES OF SOIL.

Latin Name.	English Name.	No. of Times Seen.	Percentage of Frequency (= Number of Times Seen per 100 Fields).						No. of Times Dominant.
			All Soils.	Heavy Soils.	Medium Soils.	Light Soils.	Chalky Soils.	Peat.	
Agrostis spp.	Bent grass	248	22	17	32	23	13	39	46
Capsella bursa-pastoris	Shepherd's purse	341	30	21	37	39	13	7	7
Cerastium vulgatum	Mouse-ear chickweed	83	7	6	14	6	9	—	—
Chenopodium album	Fat hen	489	44	42	55	44	34	39	32
Cirsium arvense	Creeping thistle	812	73	86	87	63	72	—	125
Euphorbia peplus	Petty spurge	25	2	2·7	2·1	2	2·7	—	—
Lychnis githago	Corn cockle	26	2·5	1·5	3	2	4	—	1
Myosotis arvensis	Field forget-me-not	165	15	19	13	13	15	—	2
Plantago lanceolata	Ribwort plantain	103	9	7	9	9	14	—	3
Polygonum aviculare	Knotgrass	625	56	58	66	56	43	23	66
Polygonum convolvulus	Black bindweed	546	49	42	64	53	30	44	22
Potentilla anserina	Silverweed	114	10	8·5	13	9	13	15	3
Ranunculus repens	Creeping buttercup	149	13	20	15	7	20	7	2
Raphanus raphanistrum	Wild radish	41	3·6	4	1·5	5	2·7	—	2
Rumex crispus	Curled dock	459	41	50	49	34	43	15	14
Scandix pecten	Shepherd's needle	137	12	15	8	8	29	—	2
Senecio vulgaris	Groundsel	365	33	39	37	32	20	7	7
Sheradia arvensis	Field madder	85	7	5	9	7	13	—	—
Stellaria media	Chickweed	501	45	48	63	42	29	23	21
Veronica agrestis	Field speedwell	218	19	17	21	21	20	—	10

The table also shows how persistently some of the worst weeds, as thistle, knotgrass, black bindweed, and fat hen, maintain their hold upon the ground in spite of the strenuous efforts of the farmer to eradicate them. The creeping thistle masters the situation more frequently than any other weed. No matter what the soil nor how carefully the land is farmed it is almost impossible to get rid of it, and it takes advantage of every opportunity to spread more and more. It occurred on 73 per cent. of the fields examined, and in 125 of these, i.e. 11 per cent., it was the chief and dominant weed, holding the worst record of all weeds in this respect.

The curled dock (*Rumex crispus*) may be dominant on any soil, and it would be rampant everywhere if it were left alone, but so much time and labour has been spent on its eradication that the presence of too many docks in normal times is a sign of bad farming and neglect. It is possible to make a clearance by persistent effort. Fat hen and chickweed are often dominant on various soils, but field speedwell, groundsel, and shepherd's purse less frequently. Most of the other weeds show some preference in their dominance. Black bindweed is frequently the chief weed on the lighter soils, but was never seen dominant on clay or chalk, whereas its close relative knotgrass is dominant on all types of soil, heavy or light, chalky or non-calcareous though it dominates rather more frequently on the lighter than on the heavier soils. Ribwort plantain and shepherd's needle are seldom abundant, but very occasionally they will dominate on chalky soil. The shepherd's needle is curiously local in its distribution. In Bedfordshire, Nottinghamshire and Derbyshire it seems to be absent from chalk, and behaves practically as a calcifuge. In Norfolk it was never seen on chalk and only occasionally on chalky loam, but in the West Country it is most prevalent on chalk and on other soils of very calcareous nature, so that in that area it is chalk-loving instead of calcifuge. This is probably one of the cases in which competition and local conditions have far more to do with distribution than the nature of the soil, though it is not very usual for such a complete inversion of the habitats to take place.

Bent grass (*Agrostis spp.*), commonly known as twitch or couch, causes much trouble in places. It may be dominant on any type of soil, and indeed in the frequency with which it is the chief weed on a field it takes third place. On the lighter soils it is frequently scuffled out and burnt in heaps,

but on heavier land it is far more difficult to eradicate, as the creeping stems are very full of vitality and each small broken piece is capable of starting a new plant on its own account.

In addition to these ubiquitous weeds which occur in such quantities as to make them an important economic factor there are a few others which are more or less uncommon but which are equally cosmopolitan in habitat. Petty spurge and field forget-me-not are widespread but never very plentiful. The pale red poppy (*P. dubium*) occurs more frequently than is recognised as it is probably often confused with the common red poppy.

Silverweed (*Potentilla anserina*) although it occurred in 10 per cent. of the fields examined was frequently in such small amounts as to be scarce. Only on three occasions was it dominant and in each case this was on chalky land. It is quite probable that this weed in spite of its general distribution has some preference for calcareous soil. Creeping buttercup, mouse-ear chickweed, field madder and wild radish are specially characterised by the number of times that they are scarce when they do occur, as is shown by the following table :—

	No. of Times Seen.	No. of Times Dominant.	No. of Times Scarce.	Per Cent. of Times Scarce.
Creeping buttercup . .	149	2	20	13
Mouse-ear chickweed .	83	—	15	18
Field madder . . .	85	—	22	26
Wild radish . . .	41	2	22	54

In addition to the weeds noted above, a number of others occur with less frequency; in the course of the investigation they were seen but twenty times or less in arable fields. The indications are, however, that most of these plants are comparatively indifferent as to soil, as they were found on all types of land.

* *Achillea millefolium* . .	Yarrow.
Æthusa cynapium . . .	Fool's parsley.
* *Bellis perennis* . . .	Daisy.
Brassica campestris . .	Field cabbage.
Cirsium lanceolatum . .	Spear thistle.
Caucalis nodosa . . .	Knotted caucalis.
* *Chrysanthemum leucanthemum*	Dog daisy.
* *Lychnis dioica* . . .	Red campion.

Nepeta glechoma . . .	Ground ivy.
Potentilla reptans . . .	Cinquefoil.
* *Prunella vulgaris* . . .	Selfheal.
* *Ranunculus bulbosus* . .	Bulbous buttercup.
* *Sisymbrium officinale* . .	Hedge mustard.
Urtica dioica . . .	Stinging nettle.

The weeds marked * were very often scarce, and it is noticeable that they are all characteristic of grass-lands or hedges, and are not commonly associated with arable land. In no single case did any weed in this list attain a position of dominance.

Thalecress (*Arabis thaliana*) may perhaps be included here though it was only seen three times, on three different types of soil, in Bedfordshire. Arable land is a very unusual habitat for this species, it being a frequenter of old walls and waste stony places and not usually appearing on cultivated soil.

(*b*) *Plants Occurring on all Soils, but less Frequently on Heavy Land.*—A small number of the weeds that are of general distribution are much less common on heavy loams and clays than they are on the lighter soils, on which as a rule they are fairly evenly distributed. The number of species that come under this heading is very restricted, as usually the weeds that are scarce on the heavy land show some definite preference for a particular type of soil, such as sand or chalk, which does not occur in this case.

TABLE II.—WEEDS OF GENERAL OCCURRENCE, BUT LESS FREQUENT ON HEAVY LAND.

Latin Name.	English Name.	No. of Times Seen.	Percentage of Frequency (= Number of Times Seen per 100 Fields).					
			All Soils.	Heavy.	Medium.	Light.	Chalk.	Peat.
Anthemis arvensis .	Corn chamomile .	38	3	·7	1·5	4	6	7
Arenaria serpyllifolia	Sandwort . .	110	10	2	12	11	16	—
Euphorbia helioscopia	Sun spurge . .	72	6	3	11	4·5	13	—
Geranium molle .	Soft crane's-bill .	84	7·5	2·7	13	7	11	—
Papaver rhœas .	Common red poppy	367	33	16	38	38	34	—

The common red poppy (*Papaver rhœas*) is so very widespread and abundant that in some districts it is one of the most difficult weeds to fight. It is popularly believed to be peculiarly a weed of sand and very light soils, but close

investigation has shown that it is really far more cosmopolitan. It is as common on medium loams as on light loams and sand, and it is also seen quite often on the heavy loams and clays. In fact the proportion of the number of occurrences in these situations reaches 50 per cent. of those on all the other soils. Poppies are frequently dominant—in 367 occurrences they took first place 93 times—but they are never dominant on clay, and but rarely on heavy loam. Here again the popular mind is astray, as the records of dominance are nearly as frequent in proportion from medium loam as they are from sand and sandy soils, though light loams have a lead in this respect. Equally striking is the frequency with which the weed is scarce—69 times in the 367 observations. Naturally enough, this scarcity is more marked on the clays and heavy loam, but it is also very noticeable on all the lighter types of soil.

Sandwort (*Arenaria serpyllifolia*) is apparently localised in its distribution. It was seen 103 times in Norfolk, but only seven times altogether in the other districts visited. It is quite possible that it may occasionally have been overlooked, as sometimes it closely resembles small forms of *Stellaria media*, but it is improbable that it would have escaped detection to any serious extent. It has a much stronger dislike of heavy soils than has *Papaver rhœas*, and also it shows a certain preference for chalk. Sandwort is rarely dominant and rarely scarce; it avoids extremes and simply takes its place as an inconspicuous member of the weed flora, seldom playing any striking part.

Soft crane's-bill (*Geranium molle*) and sun spurge (*Euphorbia helioscopia*) resemble one another in that in addition to being scarce on heavy land they are also less prevalent on the lighter soils, including sandy and light loams and sand. Soft crane's-bill was once seen dominant on sand, and is rather often scarce in quantity, but the sun spurge never dominates and is more usually scarce on any kind of soil. The latter plant is a most insignificant member of the weed community, and were it not that it thrusts itself upon one's notice by its peculiar colour and conformation, would often run great risk of being overlooked.

Corn chamomile (*Anthemis arvensis*) is less common than some of the other mayweeds, and is hardly found at all in some districts. It very occasionally dominates on light or chalky soils and is often scarce on any soil.

(*c*) *Plants Occurring on all Soils, but less Frequently on Chalk.*—The weeds in this category show a regular gradation of frequency.

(1) Plants that are merely less common on chalky soils, such as *Veronica hederæfolia* and *Veronica arvensis*.

(2) Plants that are so much less common on chalk that a dislike of such soil is suggested, as *Alchemilla arvensis*, *Lamium purpureum*, *Matricaria chamomilla*, *Matricaria inodora*, and *Poa annua*.

(3) Plants which are so infrequent on chalk that a dislike of calcareous soil is evident, as *Papaver argemone*, *Polygonum persecaria*, *Rumex obtusifolius*.

TABLE III.—WEEDS OCCURRING ON ALL SOILS, BUT LESS FREQUENTLY ON CHALK.

Latin Name.	English Name.	No. of Times Seen.	Percentage of Frequency (= Number of Times Seen per 100 Fields).					
			All Soils.	Heavy.	Medium.	Light.	Chalk.	Peat.
Veronica arvensis	Wall speedwell	80	7	8	8	8	4	—
Veronica hederæfolia	Ivy-leaved speedwell	206	18	22	15	21	9	—
Alchemilla arvensis	Lady's mantle	96	8·6	3·5	13	11	3	—
Lamium purpureum	Red dead-nettle	39	3·5	3·5	6	3	·7	—
Matricaria chamomilla	Wild chamomile	29	3	3·5	1	3	·7	—
Matricaria inodora	Scentless mayweed	181	16	16	18	19	4	15
Poa annua	Annual meadow-grass	195	17	17	25	18	4	23
Papaver argemone	Pale poppy	17	1·5	1·5	11	1·6	—	—
Polygonum persecaria	Willow-weed	132	12	2·6	12	13	·6	90
Rumex obtusifolius	Broad dock	40	3·6	3·5	4	4·5	—	—

(1) Ivy-leaved speedwell (*Veronica hederæfolia*) is of frequent occurrence and is often dominant. The plant is of a very early and ephemeral habit, and as soon as growth is completed it ripens its seeds and dies off rapidly, so that in many cases by the end of June few traces of an abundance of plants are to be seen. Consequently, it may easily happen that if fields are examined late in the season the speedwell may be missed in areas in which it dominates at an earlier date. It seems to be equally dominant on all types of soil, as even on chalk it maintains its position in this respect, although the plant is so much less frequently seen in this situation.

Wall speedwell (*Veronica arvensis*) is much less common

than its ally and usually occurs in very small quantities, never being present in any abundance.

(2) Lady's mantle (*Alchemilla arvensis*) is uncommon both on chalky and heavy land, and possibly is the more intolerant of the latter. When it does occur on clay or heavy loam it is usually scarce, but on calcareous soil it is distributed more evenly, and is often present in fair amount. Very occasionally it is dominant or sub-dominant on very light soils or sand, but as a general rule it is insignificant and inconspicuous.

Red dead-nettle (*Lamium purpureum*) always has the air of being an intruder among arable weeds, as it never seems fully at home in such surroundings. Its preference is for medium loam, and it is very rare on chalk; so rare that it may almost be considered as absent. This dead-nettle is never dominant, and never abundant, but is often present in mere traces.

The mayweeds (*Matricaria inodora* and *Matricaria chamomilla*) resemble one another in distribution, but the former is much the more common. The scentless mayweed (*M. inodora*) is frequently dominant or sub-dominant on all soils save chalk, and it is probable that it would dominate still more often if it were not for its habit of clinging to the edges and open spaces of the corn fields, and of refusing to flourish among the corn, even in places that are particularly favourable for its growth. This same habit also accounts for the frequency with which the weed seems to be scarce, as if the crop competition is extra strong the mayweed gives up the struggle at the outset and entirely fails to assert itself.

Wild chamomile (*Matricaria chamomilla*) is very rarely found on soil of any calcareous type, and probably the plant should be classified amongst those in section (3) which are intolerant of chalk. Although this mayweed is so infrequent it is sometimes dominant, usually on sandy soil, and occasionally on clay.

Annual meadow-grass (*Poa annua*) is one of the very few grasses that may fairly be regarded as a true arable weed and not as a mere survival from a previous "seeds" crop. It is frequent on all soils except those of calcareous nature and is often present in some quantity, though it is not often dominant. Very occasionally, however, it is so plentiful that it carpets the ground and even receives the local name of twitch (this occurred at Gedling in Notts), but such prevalence is unusual, the weed being easily kept down by careful cultivation.

(3) Willow-weed (*Polygonum persecaria*) stands apart from all other weeds in its habits and habitats. It is most intolerant of chalk, but otherwise seems indifferent to the nature of the soil. Sometimes it behaves like other weeds and is spread more or less evenly over the fields, or is segregated in areas that are determined by definite and marked local conditions. More usually, however, its distribution is sporadic. It occurs here and there in spots, sometimes at the bottom of a field, where the soil is moister, sometimes towards the top, where no obvious difference in water content is evident. It is abundant and usually dominant on peaty soils and grows happily in parts of fields that are often waterlogged or are churned up into thick mud by the farm traffic. When the plant occurs high and dry towards the top of a field, inquiry will often elicit the information that a spring emerges near by, or that at some periods of the year those spots are extra damp from some source of underground water. Careful consideration leads to the conclusion that soil plays but a small part in determining the distribution of willow-weed, but that a plentiful supply of underground water is essential if the plant is to flourish. Chalky soils are thoroughly well drained, and rarely have sodden spots, so the absence of willow-weed from these situations may be due either to chalk intolerance or to a deficient water supply. The weed is frequent enough on sand, and is even sometimes dominant there, but sandy soils often have damp soggy spots in which the plant can flourish, or the water table may be sufficiently near the surface to enable the roots to travel down to reach abundant moisture.

On the heavy clay fields in part of Somerset, which are low-lying and near the moors, willow-weed flourishes well and spreads uniformly over the whole area, as the necessary conditions of moisture are fulfilled everywhere, and not only in isolated spots.

Pale poppy (*Papaver argemone*) is seldom seen, either because it really does not occur, or because it is present in such small quantities that it is overlooked or confused with other larger species of poppy. It occurs anywhere except on chalky soils, but is often scarce.

Broad dock (*Rumex obtusifolius*) must be regarded as an interloper among arable weeds. It seems to object strongly to chalk or else it so happened that it had been cultivated out of existence in every field visited during the course of the investigation. The plant is essentially a weed of waste places,

and even when it flourishes well in the corner of the fields, hedgerows, etc., it rarely migrates among the crops. It is, however, difficult to pass judgment in this respect, as the weed is so big and so obnoxious that when it does appear it is usually eliminated with the greatest possible speed by a good farmer.

B. *Weeds Specially Associated with Heavy Land.*

(*a*) *Plants Characteristic of Heavy Land* (*Clay and Heavy Loams*).—There is no weed so exclusively associated with clay and heavy loam that it may be described as "symptomatic," but a very few are so much more often seen on such soils than on any other that perhaps they may fairly be called "characteristic". None of the five weeds classified thus are of frequent occurrence, as naturally the close association of a plant with a particular type of soil considerably limits its distribution.

TABLE IV.—WEEDS CHARACTERISTIC OF HEAVY LAND (CLAY AND HEAVY LOAMS).

Latin Name.	English Name.	Total Occurrence on all Soils.	Percentage of Frequency (= Number of Times Seen per 100 Fields).				
			All Soils.	Clay.	Heavy Loam.	Chalk.	Other Soils.
Anthemis cotula	Stinking mayweed	16	1·4	4	1	·6	1
Geranium dissectum	Cut-leaved geranium	19	1·7	4	4	—	1·2
Plantago media	Hoary plantain	18	1·6	7	1	—	·7
Ranunculus arvensis	Corn buttercup	49	4	14	6	3	2
Alopecurus agrestis	Black bent	54	5	14	10	5	2

Stinking mayweed (*Anthemis cotula*), although so seldom seen, is apparently closely associated with clay, on which it is even sometimes dominant. When it does occur on other soils very little of it is present as a rule, and it is often in such mere traces as to be scarce.

Cut-leaved geranium (*Geranium dissectum*) is equally at home on clay and heavy loam, but curiously enough it has been seen to reach a position of sub-dominance on a light loam, at Flitwick (Beds). It does not seem to occur on chalk.

Hoary plantain (*Plantago media*) has a most decided preference for clay soil, and it is usually regarded by farmers as a sign that the land is in good heart. It is never present in any quantity, and is seldom seen on arable land.

Corn buttercup (*Ranunculus arvensis*), though very local in occurrence, is sometimes a bad weed on heavy wheat land, and the heavier the land the more likely is the plant to cause trouble. It is sometimes dominant, and the presence of the seeds in the corn tends to depreciate the value of the wheat considerably as so much more cleaning is necessitated. The weed is far more characteristic of clay and heavy loam than appears from the table, for although it occurs on the other soils as indicated it is usually so scarce that only close observation reveals its presence. Probably in many of these cases it has simply sprung from stray seeds introduced when the crop was sown.

The inclusion of black bent (*Alopecurus agrestis*) in this list may perhaps be criticised, as it occurs quite frequently on other soils and is also dominant on them. Nevertheless, the preference for clay and heavy loam is so marked that a point may be stretched to include it among the characteristic heavy land weeds. Black bent is capable of doing much damage among corn crops but happily does not usually occur in any quantity, its habit being such that ordinary methods of rotation farming keep it in check. Occasionally, though, it has been seen dominant on clay, chalk, and medium loam, and, when it does occur, is not often scarce but usually present in appreciable amount.

(*b*) *Plants Common on Heavy Land, but also of General Distribution.*—Several of the most common and abundant weeds are found distributed over every type of soil, but nevertheless they occur more frequently and more plentifully on the heavier soils. The frequency with which the weeds in this class occur is in striking contrast with the scanty distribution of those plants which are really characteristic of the heavy soils. These weeds may be divided into two distinct sections.

(1) Plants which flourish equally well on chalk.

(2) Plants which do not occur so plentifully on chalk.

(*a*) With distinct preference for the heavier soils.

(*b*) Equally plentiful on heavy and medium soils.

In both cases the lighter loams and sand afford less congenial habitats.

TABLE V.—WEEDS COMMON ON HEAVY LAND, BUT ALSO OF GENERAL DISTRIBUTION.

Latin Name.	English Name.	No. of Times Seen.	Percentage of Frequency (= Number of Times Seen per 100 Fields).					
			All Soils.	Heavy.	Medium.	Light.	Chalk.	Peat.
1. Flourish Equally Well on Chalk.								
Convolvulus arvensis	Bindweed	599	54	65	70	42	60	—
Plantago major	Greater plantain	208	19	23	23	14	21	—
Senebiera coronopus	Swine cress	24	2	3·5	2·6	1	3·3	—
Sonchus arvensis	Corn sow-thistle	296	27	42	28	16	36	7
2. Occur less Frequently on Chalk.								
(*a*) *Distinct Preference for the Heavier Soils.*								
Agropyron repens	Couch-grass	167	15	24	15	13	7	7
Brassica sinapis	Charlock	383	34	53	34	23	42	7
Euphorbia exigua	Dwarf spurge	118	11	22	14	3	13	—
Galium aparine	Goosegrass	278	25	43	29	13	30	15
Tussilago farfara	Coltsfoot	226	20	40	27	10	13	—
(*b*) *Equally Plentiful on Heavy and Medium Soils.*								
Atriplex patula	Orache	167	15	28	28	7	3	15
Equisetum arvense	Horsetail	268	24	33	34	20	8	15
Lapsana communis	Nipplewort	37	3·4	5	5	2	2·6	—
Mentha arvensis	Corn mint	158	14	21	19	11	6	—
Veronica tournefortii	Large field speedwell	290	29	37	37	21	12	—

(1) *Plants which Flourish Equally Well on Chalk.*

Corn sow-thistle (*Sonchus arvensis*) has a decided liking for heavy soils, but is nearly as common on calcareous land. In these two habitats it is more often dominant than elsewhere. Considering the frequency with which the weed occurs it does not often take the first place, but this may partly be due to the fact that it is fond of growing among cereal crops and so is liable to be pulled up, being a very conspicuous plant, especially when in flower.

Greater plantain (*Plantago major*) has much the same distribution as the corn sow-thistle, except that it is more often seen on medium soils. Although it is so common it is rarely present in any quantity, and in all districts investigated it was only once seen dominant on arable land, on clay.

This weed is more frequent on grass-land than on ploughed land.

Swine cress (*Senebiera coronopus*) is a characteristic little plant, which is not very often noticed. It often congregates near the gateways of fields, in the cart ruts, instead of scattering evenly over the fields. It is hardly ever dominant or present in great quantity, and is rarely seen on any of the lighter soils.

Bindweed (*Convolvulus arvensis*) is one of the commonest of all weeds, so common that it is rather difficult to say that it has any real preference as to soil. It seems evident, however, that it is less happy on the lighter types of soil. This is shown by the frequency with which the weed occurs in the different habitats and also by the number of times it predominates on the various soils. It is very often dominant or sub-dominant on clay, heavy and medium loam, and fairly often so on chalk, whereas on the light sandy soils it is less frequently dominant and more often scarce. The abundance of this weed may be gauged by the fact that in one occurrence out of every five it is either dominant or sub-dominant, usually the former. This is largely due to its habit of growth, as the long creeping underground parts defy all efforts to clear them out, especially on the heavy land, and also the aerial stems cling so closely to the crops among which they scramble that when once growth has fairly started it is almost impossible to remove the weed without seriously damaging the crop.

(2) *Plants which do not Occur so Frequently on Chalk.*

(*a*) *With Distinct Preference for the Heavier Soils.*

Coltsfoot (*Tussilago farfara*) expresses a most decided preference for heavy soils. The heavier the soil, the more likely is coltsfoot to be present, and as the soil gets lighter, so does the percentage of frequency of this weed decrease. Nevertheless, it may be dominant on any type of soil, clay, medium loam, light loam, sand, chalk, or gravel. Considering the frequency with which the plant occurs it is not very often dominant, but this may be largely due to the special attention that farmers pay to its eradication. This same fact may also tend to decrease the frequency with which it is seen on the lighter soils, and to emphasise its universal occurrence on heavy land. The underground parts penetrate the soil so deeply that it is exceedingly difficult to remove them effectively from heavy soil by any of the usual methods of cultivation,

but on sand and light loam a better clearance can be effected. It is often said that the presence of coltsfoot indicates an easily available supply of underground water, or a high water table, but definite confirmation of this statement is wanting The plant is often one of the first to colonise newly made dumps, railway embankments and similar "made" soils in which the water supply tends to be deficient rather than liberal and in which the water table or available underground water lies at a considerable distance below the surface. It also comes in when the nitrogen content of the soil is reduced, as on the unmanured plot and that receiving minerals only on the Broadbalk field at Rothamsted.

Goosegrass (*Galium aparine*) is very widespread, but shows as strong a preference for heavy land as coltsfoot does. As an arable weed, however, it is less plentiful in quantity and is often scarce on all kinds of soil, especially light land, though it usually occurs in appreciable quantity on chalk. It is seldom dominant in comparison with its frequency of occurrence, but this dominance is distributed over all soils and is not confined to heavy land.

Couch-grass (*Agropyron repens*) is regarded in many districts as one of the most pestilential of weeds. Every small portion of its rhizome is capable of originating a new plant, and even with the most careful cultivation it is difficult to avoid scattering the pieces broadcast. Consequently, couch-grass is very often dominant, on any type of soil, although in its occurrence it seems to show a definite preference for heavy land. It is quite possible that this preference is not a true one, and this is supported by the frequent dominance on sand. On light soil it is comparatively easy to scuffle out the creeping rhizomes without breaking them, and so destroy them wholesale. This cannot be done on heavy land, as every attempt at removal breaks the rhizome and leaves innumerable fresh starting-points for the weed in the soil. Consequently it may well be that couch-grass is in reality cosmopolitan as to soil, but that methods of cultivation have given it a false appearance of preferring heavy land.

Dwarf spurge (*Euphorbia exigua*) is one of the less abundant weeds which makes no important contribution to the economy of the weed flora, although it is of frequent occurrence. The preference for heavy land is very strong, and it has a marked objection to sand and gravel. It is never the chief weed, but on one occasion, at Inglescombe, near

Bath, it was sub-dominant; in a large proportion of instances it only occurs in traces, isolated individuals here and there being the sole representatives.

The true charlock (*Brassica sinapis*) needs to be carefully distinguished from some half dozen other weeds which pass under the same name. Charlock does not exhibit such a marked preference for heavy soil as the foregoing weeds, but a consideration of its dominance or scarcity on the various soils show that it has a very strong preference for the heavier land. On clay, heavy and medium loam and chalk it is very often dominant, but on the light loams and sand it comparatively seldom reaches such a position. On the other hand, it is much more often scarce on the lighter soil, indicating that the habitat is less congenial. The preference for heavy land in this case is probably real, as the plant has no underground part which aids in reproduction, but is entirely dependent upon seed for its propagation. Charlock is very generally considered to be a chalk weed, but investigation shows that in many cases on the chalk the dominant "charlock" is really white mustard (*Brassica alba*).

(β) *Equally Plentiful on Heavy and Medium Soils.*—The weeds described above all prefer really heavy land (heavy loams and clay) to any other type of soil. A few weeds, however, are as much at home on the medium loams, but are much less prevalent on the lighter soils and chalk.

The large-flowered field speedwell (*Veronica tournefortii*) is really an alien, but since its introduction it has spread so rapidly that it is now one of the most common of arable weeds and has to a large extent usurped the place of the ordinary field speedwell (*Veronica agrestis*). This fact has not been fully recognised, and as in many points the two plants very much resemble one another *V. tournefortii* is still easily overlooked and confused with *V. agrestis* unless special care be taken. In fact, although it was reported from as many as 29 per cent. of the fields visited in the Rothamsted investigation it was certainly present more frequently, as for two years, in Bedfordshire and the West Country, we ourselves failed to make the distinction and put all records under *Veronica agrestis*. Long,[1] too, fails to distinguish between the two species in his list of weeds, though Buckman[2] in 1855 realised the difference.

[1] Long, H. C. (1910), "Weeds of the Farm and Garden," p. 399.

[2] Buckman (1855), "On Agricultural Weeds," *Jour. Roy. Ag. Soc.*, XVI, p. 364.

Heavy loam provides a rather more congenial habitat for *V. tournefortii* than clay, the plant is as fully at home on medium loam as on the heavier soils, and it exhibits some dislike of chalky soil. This speedwell is occasionally dominant on various soils, usually on heavy loams, but probably as time goes on it will become much more prevalent and widespread if its progress continues to be as rapid as it has been of late years.

Horsetail (*Equisetum arvense*) and corn mint (*Mentha arvensis*) are similar in distribution to the large-flowered speedwell. Horsetail is often dominant on various soils, chiefly on clay and medium loam, but it would probably dominate to a much greater extent if it were allowed to. It is, however, such a troublesome pest that special efforts are directed towards its eradication, and the success of these efforts is shown by the number of fields from which the weed is recorded as scarce. The long underground parts enable the plant to spread over wide areas, and it is difficult to clear the soil of the weed when once it has obtained a firm hold, especially on heavy land. It is abundant at Rothamsted on the unmanured plot of Broadbalk wheatfield.

Orache (*Atriplex patula*) is essentially a weed of heavy and medium soil, although when it does occur on the light soil it is often very plentiful and even dominant. Many farmers fail to recognise this weed, as in some ways it closely resembles fat hen (*Chenopodium album*), especially in the early stages of growth, and the idea is prevalent that the low-spreading plant of orache is merely fat hen that has been cut down or has met with other injury during growth and so has spread out instead of growing into the tall form characteristic of the *Chenopodium*. Fat hen, however, is much more widely distributed, and does not show the same preference for heavy and medium soil as orache. Orache is not very often dominant considering how often it occurs, but it is usually present in some quantity. The seeds are very tenacious of life and can survive burial in the soil at considerable depths[1] for many years, starting into active growth if ever conditions become favourable.

Nipplewort (*Lapsana communis*) is uncommon and scarce as an arable weed. It is very rarely present in any appreciable quantity, though it was once seen dominant at Staythorpe

[1] Brenchley, W. E. (1918), "Buried Weed Seeds," *Jour. Ag. Sci.*, IX, pp. 1-31.

(Notts). Possibly it is more usual as a garden than as a field weed.

C. *Weeds Characteristic of Sand and very Light Soil Deficient in Lime.*

Much of the sandy and very light land in this country in its uncultivated condition is characterised by a marked deficiency in lime content, so much so that such soils are often said to be "acid" or "sour". Soil conditions such as these are not conducive to the healthy growth of a great variety of plants, but there are a few weeds which are perfectly at home and which revel in the very conditions that are untenable for many others. The half dozen plants in this category are seldom seen on ordinary soil, either because there is too much lime present to please them or because they are so impatient of competition that directly other plants are able to put up a fight the "sour land" weeds give up the struggle at once.

TABLE VI.—WEEDS CHARACTERISTIC OF SAND AND VERY LIGHT SOIL, DEFICIENT IN LIME.

Latin Name.	English Name.	No. of Times Seen.	Percentage of Frequency (= Number of Times Seen per 100 Fields).				
			All Soils.	Sand and Bake.	Sandy Loam and Gravel.	Chalk.	Other Soils.
Chrysanthemum segetum	Corn marigold .	24	2	7	3·5	—	·3
Gnaphalium uliginosum	Marsh cudweed	32	3	4	10	—	3
Rumex acetosella . .	Sheep's sorrel .	97	9	20	14	—	5
Scleranthus annuus .	Annual knawel	37	3	11	7	—	·3
Spergula arvensis .	Spurry . .	218	19	52	30	—	9
Urtica urens . .	Small nettle .	25	2	6	1·7	—	1·4

Spurry (*Spergula arvensis*) (Fig. 36) is the greatest bugbear in the shape of weeds that farmers have to deal with on sandy land. It is an annual plant which forms large quantities of seeds, and when once fairly established it is almost impossible to eradicate it. Liming does a great deal to help, but the amount of lime that would be necessary to eradicate the spurry would ruin the soil, as the dressing would need to be so abnormally heavy that lime poisoning would probably be set up. Spurry is so closely associated with light sandy soils that one expects to find it there, and, more than that, to find it dominant in many cases. As

a matter of fact, it is the pre-eminent weed in at least one-third of the cases in which it is found, and further, it is relatively seldom scarce except in the few instances in which

FIG. 36.—SPURRY (*Spergula arvensis*).

it appears on heavier land. The lighter the soil, the more likely is spurry to occur, and so it is even more closely associated with sand than with sandy loam and gravel.

Annual knawel (*Scleranthus annuus*) (Fig. 37) is an inconspicuous weed that is easily overlooked, especially as it is

really not very common. When it does occur, it is often present in abundance, especially on sand. It is very rarely seen on any soil heavier than gravel.

Small nettle (*Urtica urens*) is another weed that is more

FIG. 37.—ANNUAL KNAWEL (*Scleranthus annuus*).

often seen on sand than elsewhere, but never on chalk. It is not of frequent occurrence, and it is very often scarce, so that it plays little part in the general weed economy.

Sheep's sorrel (*Rumex acetosella*) (Fig. 38) is common on all the lighter soils, though it has some preference for sand. This may be one of the cases in which the lime deficiency has

more to do with the plant's occurrence than has the texture of the soil. It occurs occasionally on nearly all types of land,

FIG. 38.—SHEEP'S SORREL (*Rumex acetosella*).

and is always regarded as being an indicator of lack of lime, but it is not nearly as frequent on the heavier land as is its ally *Rumex acetosa*. On sandy and gravelly soils and also on peat sheep's sorrel is frequently dominant, and apart from

arable land it is a characteristic feature on sandy and gravelly heaths and commons where lime is lacking from the soil.

Corn marigold (*Chrysanthemum segetum*) (Fig. 39) is shrouded in a slight air of mystery. Obviously enough sandy soils are congenial to it, as it usually occurs in such situations and is relatively often dominant there, whereas Buckman [1] states that it is an index of rich soil. But the weed is by no means common, being very local, and even in the same district it is localised to certain fields. It is evident that some other factor, in addition to lime deficiency and soil texture, determines its distribution, and it seems possible that this factor may be that of moisture. A comparison of the number of occurrences with the number of times it is dominant suggests that the plant is ultra-particular as to its habitat and is most intolerant of any untoward circumstance, but that when its peculiar needs are met it is

FIG. 39.—CORN MARIGOLD (*Chrysanthemum segetum*).

[1] Buckman (1855), *Jour. Roy. Ag. Soc.*, XVI, p. 363.

capable of gaining and keeping the upper hand to the detriment of the crop amongst which it finds itself.

Marsh cudweed (*Gnaphalium uliginosum*) belies its name utterly in its distribution as an arable weed. Far from seeking moist spots in which to flourish it is associated with light sandy soils which are well drained and which seldom have any superfluous water held up in them. This is the only one of this class of weeds which is more frequent and abundant on sandy loam than on sand. It is rarely present in any quantity, but is often scarce, though it was once seen to be sub-dominant at Woburn (Beds). Buckman suggests that it is a good index of damp subsoil.

D. *Weeds Associated with Chalk.*

The weeds that are usually associated with chalk can be divided into three distinct classes according to the degree of preference for chalky soil that they exhibit.

(*a*) Plants characteristic of chalk.

(*b*) Plants with a definite preference for chalk, but also occurring on all soils.

(*c*) Plants with a definite preference for light and sandy soils as well as for chalk.

(*a*) *Plants Characteristic of Chalk.*—The true chalk lovers are very few in number, and even they are not strictly confined to the one habitat, though the proportion of occurrences on other types of soil is very small. White mustard (charlock), hardhead, and toadflax are the three outstanding plants in this group, while corn gromwell, wild mignonette and lamb's lettuce are equally characteristic but much less frequently seen.

TABLE VII.—WEEDS CHARACTERISTIC OF CHALKY SOILS.

Latin Name.	English Name.	No. of Times Seen.	Percentage of Frequency (= Number of Times Seen per 100 Fields).					
			All Soils.	Clay and Heavy Loam.	Medium Loam.	Light Soils.	Chalky Soil.	Peat.
Brassica alba . .	White mustard .	72	6·5	1	3	6	20	—
Centaurea nigra .	Hardhead . .	56	5	1·5	2	1·8	26	—
Linaria vulgaris .	Toadflax . .	66	6	1·5	—	2	33	—
Lithospermum arvense	Corn gromwell .	21	2	·8	—	1	8	—
Reseda lutea . .	Wild mignonette	27	2·5	·4	·5	1·4	12	—
Valerianella olitoria	Lamb's lettuce .	5	—	—	—	—	3	—

White mustard or charlock (*Brassica alba*) is often found growing alongside the ordinary charlock (*Brassica sinapis*) on chalky soils, though it is not so frequent in occurrence even in such favoured situations, but whereas the *Brassica sinapis* is abundant on all types of soil with a leaning towards the heavy land, *Brassica alba* is rarely seen except on typical chalk land and in a less degree on light soils. The two species are very similar in habitat and colour of flower, and farmers rarely distinguish between the two forms, the chief difference being in the shape of the leaves and the character of the fruits. When white mustard does occur it is very often dominant, particularly on chalk, where it is the chief weed every second time that it occurs. Curiously enough, though the species is so uncommon on the heavy and medium land, yet in such situations it is sometimes dominant instead of being occasional or scarce, as is usually the case with plants that show preference for special types of soil when they occur outside the preferred habitat.

Hardhead (*Centaurea nigra*) is as common on chalky soil as the white mustard, but it is more or less insignificant in quantity, and never reaches a position of dominance. The plants are larger and therefore attract attention, but the species is more associated with pasture than with arable land.

Toadflax (*Linaria vulgaris*) and wild mignonette (*Reseda lutea*) are always connected in the popular mind with chalky land, and indeed they seem curiously characteristic and conspicuous, although they are rarely present in any considerable quantity. Corn gromwell (*Lithospermum arvense*) and lamb's lettuce (*Valerianella olitoria*) are most insignificant, occurring but seldom and in very small quantities, but nevertheless they are just as characteristic of chalky soils as are the more abundant species like white mustard and toadflax.

(*b*) *Plants with a Definite Preference for Chalk, but also occurring on all Soils.*—This class of weeds is much better represented than that of plants characteristic of chalk. The plants in this section do not exhibit violent dislike to any type of soil, but they are certainly much more often associated with chalky land than with any other. Some of the commoner weeds come under this heading, such as pimpernel, fumitory, field pansy, and campion, and only a very few are at all infrequent in distribution on arable land, these being hogweed, greater knapweed, round leaved toadflax, and wild carrot. This is only another instance of what usually occurs. Plant

species that are really characteristic of any type of soil are few in number and comparatively infrequent in distribution, whereas plants which merely exhibit a preference for a particular soil are represented by several species, and are far more often met with.

TABLE VIII.—WEEDS WITH A DEFINITE PREFERENCE FOR CHALK BUT ALSO OCCURRING ON ALL SOILS.

Latin Name.	English Name.	No. of Times Seen.	Percentage of Frequency (= Number of Times Seen per 100 Fields).					
			All Soils.	Heavy Soils.	Medium Loam.	Light Soils.	Chalky Soils.	Peat.
Anagallis arvensis	Pimpernel	205	18	18	18	16	40	—
Bartsia odontites	Red bartsia	74	7	7	7	4	15	—
Centaurea scabiosa	Greater knapweed	34	3	·4	2·6	3	9	—
Daucus carota	Wild carrot	38	3·4	·8	4	2	12	—
Fumaria officinalis	Fumitory	230	21	12	25	21	31	—
Heracleum sphondylium	Hogweed	33	3	3	4	1	9	—
Linaria spuria	Round-leaved toadflax	8	·7	·4	1·6	·2	2	—
Lychnis vespertina	White campion	191	17	8	16	18	31	—
Ranunculus acris	Tall buttercup	43	4	5	1·6	3	6·5	7
Scabiosa arvensis	Field scabious	121	11	4	8	8	37	—
Silene inflata	Bladder campion	100	9	3	8	6	30	—
Taraxacum vulgare	Dandelion	96	9	10	8	5	18	23
Viola tricolor	Pansy	245	22	9	19	25	33	69

Of all the weeds classified in this list field scabious (*Scabiosa arvensis*), bladder campion (*Silene inflata*), wild carrot (*Daucus carota*), and greater knapweed (*Centaurea scabiosa*) show the greater preference for chalky soil, though pimpernel (*Anagallis arvensis*) and hogweed (*Heracleum sphondylium*) run them very close.

Field scabious (*Scabiosa arvensis*) is quite commonly distributed, but it rarely occurs in any quantity, and was never seen to reach a position of dominance.

Bladder campion (*Silene inflata*) is perhaps rather less frequently seen than the scabious, but it occurs in greater abundance, and occasionally forms the chief weed in the flora on various types of land.

Wild carrot (*Daucus carota*) is probably less usual as an arable than as a pasture weed, but in spite of its infrequent occurrence it is sometimes present in such abundance as to be dominant on light and chalky soils.

Greater knapweed (*Centaurea scabiosa*) is another of the

more uncommon weeds, being much less frequent than its ally *C. nigra*. Usually it is not present in any abundance, but it was once seen dominant on sand in Norfolk.

Poor-man's-weather-glass or pimpernel (*Anagallis arvensis*) is one of the more insignificant weeds which are fairly widespread but rarely occur in any quantity. Nevertheless, it is in no danger of being overlooked as it attracts much interest and attention from the fact that it is said to close on the approach of rain, thus providing a useful weather glass for country folk. Very occasionally it is present in such abundance as to be dominant, and it has been found so both on heavy clay and chalky loam.

Hogweed (*Heracleum sphondylium*) is not very common as an arable weed, as it much prefers the hedgerow for its habitat. It never dominates in the fields and is frequently represented by solitary individuals, interlopers that have wandered out from their normal position in the hedges.

A few of the more common weeds, such as fumitory, campion, field pansy, are not quite as closely associated with chalky soil as those described above, though the preference is still very marked.

Fumitory (*Fumaria officinalis*) is ephemeral in nature, and disappears from the fields at a comparatively early date, so that it may be more abundant in reality than the figures indicate. It is quite frequently dominant, and still more often scarce, but both these observations may need to be modified in consideration of the fugitive nature of the species. As a matter of fact *Fumaria officinalis* includes a number of species which have not been distinguished in the field, and some of these are more ephemeral than others, so that the records obtained for fumitory in the later months of the season are largely dependent upon the particular species occurring in the districts examined.

White campion (*Lychnis vespertina*) is very widely scattered, but it is seldom present in any amount, and indeed is scarce in two out of every five times it occurs. It is quite probable that most of the seed is introduced with clover and other small crop seeds, and this would largely account for the widespread distribution and for the fewness of the plants found.

Field pansy (*Viola tricolor*) is also commonly found in small quantities, and was only once seen dominant on gravel in Nottinghamshire.

Red bartsia, tall buttercup, dandelion, and round-leaved

toadflax are less usually seen in arable fields, and are not often present in any quantity. Very occasionally red bartsia and tall buttercup dominate, but generally they are quite insignificant. Red bartsia (*Bartsia odontites*), however, attracts a certain amount of unfavourable notice on account of its semi-parasitic nature, described elsewhere (p. 102).

(*c*) *Plants with a Definite Preference for Light and Sandy Soils as well as for Chalk.*

TABLE IX.—WEEDS WITH A DEFINITE PREFERENCE FOR LIGHT AND SANDY SOILS AS WELL AS FOR CHALK.

Latin Name.	English Name.	No. of Times Seen.	Percentage of Frequency (= Number of Times Seen per 100 Fields).					
			All Soils.	Heavy.	Medium.	Light.	Chalk.	Peat.
Carduus nutans	Musk thistle	21	2	—	1·6	2·4	4	—
Filago germanica	Cudweed	15	1·3	—	1	2·2	1·3	—
Geranium pusillum	Small-flowered crane's-bill	30	2·7	·8	2	3·2	5	—
Lamium amplexicaule	Henbit	30	2·7	·4	1·6	4	4	—
Legousia hybrida	Corn campanula	37	3	1·1	2·6	4	6	—
Lycopsis arvensis	Small bugloss	30	2·7	—	—	5·5	1·3	—
Veronica serpyllifolia	Thyme-leaved speedwell	7	·6	—	—	1·4	—	—

The species in this list are on the whole very insignificant members of the weed flora. Not one of them occurs at all frequently, and it is very seldom that any are present in any abundance. On one or two occasions musk thistle (*Carduus nutans*) and small-flowered crane's-bill (*Geranium pusillum*) were the chief weeds in the fields, but none of the others were ever dominant. Yet, in spite of their comparative scarcity, several of these plants are very interesting, and attract much attention. Musk thistle, cudweed, henbit, corn campanula, and small bugloss all have peculiar characteristics of habit or colour which mark them out among their associates, and consequently an observer often receives the impression that these weeds are more common than they really are, and the results of the numerical analysis come in the nature of a surprise.

E. *Weeds Associated with Peat Soils.*

Many peat soils are particularly difficult to cultivate owing to their peculiar nature, and in most cases such soils are left to their own devices or used for grazing or hay instead of for

arable cultivation. This, of course, does not apply to the Fen land, which is of a specially rich nature, and which is not acid like many of the other peat lands.

Weed Flora of Twelve Fields on Everton Carr, Arranged in Numerical Order of Frequency.

Latin Name.	English Name.	No. of Times Seen.	No. of Times Dominant.	Remarks.
Polygonum persecaria	Willow-weed	10	4	
Spergula arvensis	Spurry	9	4	
Rumex acetosella	Sheep's sorrel	9	2	Also once sub-dominant.
Galeopsis tetrahit	Hemp nettle	9	1	
Viola tricolor	Field pansy	8	—	Often in patches.
Agrostis stolonifera?	Bent grass	5	2	Sometimes in patches.
Chenopodium album	Fat hen	5	—	
Polygonum convolvulus	Black bindweed	5	—	
Taraxacum vulgare	Dandelion	3	—	
Stellaria media	Chickweed	2	—	Only in small amount.
Equisetum arvense	Horsetail	2	—	
Atriplex patula	Orache	2	—	
Potentilla anserina	Silverweed	2	—	
Polygonum aviculare	Knotgrass	2	—	
Hypochæris radicata	Cat's ear	2	—	
Rumex crispus	Curled dock	2	—	
Poa annua	Annual meadow grass	2	—	Scarce on both occasions.
Brassica sinapis	Charlock	1	—	
Sonchus arvensis	Corn sow-thistle	1	—	
Anthemis arvensis	Corn chamomile	1	—	
Achillea millifolium	Yarrow	1	—	
Ranunculus repens	Creeping buttercup	1	—	
Senecio vulgaris	Groundsel	1	—	All scarce.
Lychnis flos-cuculi	Ragged robin	1	—	
Matricaria inodora	Scentless mayweed	1	—	

The peat on Everton Carr, Nottinghamshire, provides an interesting instance of the weeds that occur when wet, acid peat land is cultivated. The weed flora is very restricted in the number of species composing it, but a few are markedly characteristic of the situation and occur in most fields, often in considerable quantity: Willow-weed (*Polygonum persecaria*), spurry (*Spergula arvensis*), sheep's sorrel (*Rumex acetosella*), and bent grass (*Agrostis stolonifera?*), are usually present and often dominant, and hemp nettle (*Galeopsis tetrahit*) is also very common, though it seldom dominates the whole of a

field. In addition to these fat hen (*Chenopodium album*), black bindweed (*Polygonum convolvulus*), and field pansy (*Viola tricolor*) occur frequently in greater or less abundance. The other species found are less characteristic of peat soils and are more erratic in their distribution. An analysis of the weeds seen on twelve fields on Everton Carr on 28th June, 1915, may be of interest, as the list (see page 151) shows very clearly how severely the personnel of the weed flora is limited by the habitat.

Comparison of Distribution of Arable Weeds as Recorded by Various Observers.

It is instructive to compare the absolute quantitative results obtained by the Rothamsted methods of working with the more empirical results set forth by other workers from records of practical experience and accumulated general observations. Two convenient lists are available, given by Buckman [1] (1855) and Long [2] (1910).

A close comparison of the habitats of the various weeds as given by the three sets of observations shows most remarkable agreement. This agreement is absolute, except with regard to some thirty-seven species, and with these the discrepancy is usually slight and due to the fact that one or other investigator has made a closer association of the weed in question with some particular soil. This may easily happen, as local variations in distribution are bound to influence the judgment of the worker to some extent. For instance, Long and Buckman associate *Euphorbia exigua* with loams, whereas the writer finds it on all types of soil, with some preference for heavier land. Again, Long associates *Scabiosa arvensis* with all soils indifferently. Buckman confines it to calcareous land, whereas the writer finds it on all soils, with a preference for chalk, thus reconciling the opinions of the other two authorities. Similar reconciliations can be effected in most instances where discrepancy exists, and the only cases in which the variations in the lists are significant are given in the following table, any result which is seriously disputed being put into italics:—

[1] Buckman (1855), "On Agricultural Weeds," *Jour. Roy. Agric. Soc.*, XVI, pp. 359-367.

[2] Long, H. C. (1910), "Common Weeds of the Farm and Garden," pp. 384-408.

TABLE SHOWING THE VARYING HABITATS ATTRIBUTED TO CERTAIN WEEDS.

Latin Name.	Common Name.	Buckman, 1855.	Long, 1910.	Brenchley, 1910-1915.
Alchemilla arvensis.	Field lady's mantle.	Calcareous soil.	Dry loams and calcareous soils.	All, with some dislike of chalk.
Alopecurus agrestis.	Black bent.	Sterile clays.	*Dry sandy soils.*	Characteristic of clays and heavy loams.
Convolvulus arvensis.	Bindweed.	All soils, most frequent in sandy soils.	Nearly all soils.	All, prefers heavier soils and chalk.
Equisetum arvense.	Horsetail.	Sandy soils.	Generally damp soils.	All, prefers heavier soils.
Galium aparine.	Cleavers.	Loamy soil.	Light, open soils.	All, prefers heavier soils.
Geranium dissectum.	Cut-leaved geranium.	Calcareous and loamy soils.	Sandy, loamy, calcareous soils.	Characteristic of clay and heavy loam.
Linaria vulgaris.	Yellow toadflax.	Loamy soil.	Damp loams.	Characteristic of chalky soils.
Lychnis vespertina.	White campion.	—	Sandy soil.	All, prefers chalky soils.
Papaver rhœas.	Red poppy.	"*A most exact indicator of sandy soil.*"	Nearly all soils.	All, not much on heavy land.
Plantago media.	Hoary plantain.	Everywhere.	Dry calcareous soils.	Characteristic of clay and heavy loam.
Ranunculus arvensis.	Corn buttercup.	Stiff soil, "hungry clay".	All soils.	Characteristic of clay and heavy loam.
Rumex acetosella.	Sheep's sorrel.	—	*All dry soils.*	Characteristic of light and sandy land. Avoids chalk.
Scandix pecten.	Shepherd's needle.	—	Light soils and chalk.	All soils.
Spergula arvensis.	Spurry.	Sandy soil.	*All soils.*	Sand. Avoids chalk.
Urtica urens.	Small nettle.	Loamy soil.	All soils.	Characteristic of sand and light soils. Avoids chalk.

Some of the discrepancies in the above table are such as might be reconciled or eliminated with a wider range of observations, but a few of the statements are so diametrically opposed to one another that it is difficult to see how they could be made to agree.

Alopecurus agrestis is peculiarly at home on heavy clay and the heavier soils, so much so that it seems to be characteristic. In the Rothamsted experiments it was only seen once on sand and four times on gravel, out of a total of fifty-four observations, a fact which gives no corroboration to Long's statement that it is a weed of dry sandy soils.

Papaver rhœas is popularly associated with light soils, and indeed, often occurs so abundantly in such situations as to nickname the whole district, e.g. "Poppyland" in Norfolk. Nevertheless, an unbiassed analysis shows that whereas poppies are often overwhelmingly abundant on some light soils, yet they are universally distributed over nearly all soils, although they are present in smaller quantities on the really heavy types of land. It has already been pointed out that *Papaver rhœas* was observed as a dominant on every kind of soil except clay and peat, so that there seems to be no justification for Buckman's remark that this species is "a most exact indicator of sandy soil". As a matter of fact, poppies are impatient of certain types of sandy soil, and the acid sands that bear heavy crops of spurry rarely carry many poppies, while the chalky sands that are so congenial to the latter are unfavourable to the growth of spurry.

Long's statement that *Rumex acetosella* occurs on all dry soils is misleading, as this includes the chalky land which is obnoxious to the species. The writer's observations go to show that sheep's sorrel is characteristic of light and sandy land, but that it is seldom seen on chalk, so much so that the plant is regarded as one of the few "indicators" of acid soil. Being shallow rooted it may be found as a denizen of a very thin layer of sour land overlying chalk, as happens in the "bake" on the top of some of the Wiltshire Chalk downs.

Spergula arvensis is another plant that indicates a deficiency of chalk, and again it is misleading to describe it as occurring on all soils. The plant is still more characteristic of sand and very light soil than the sheep's sorrel, and even when it puts in an occasional appearance on heavier land it is usually very scarce. Its dislike of chalk is so marked that although it has been noted 218 times it has never once been observed on

any type of calcareous land, whether chalk, chalky loam, chalky sand, or red land.

In a few cases the differences between the three tables are possibly caused by the local distribution of certain weeds. If plants are at all localised it is quite likely that utterly different results may be obtained by various workers or by the same worker in different areas. As an instance of this, *Scandix pecten* (shepherd's needle) may be cited. In Wiltshire, in 1911, this plant was almost exclusively associated with chalk and red land, and it occurred frequently enough to be considered a chalk lover. In Norfolk, in 1912, and in Notts and Derby in 1915 the same species was not once seen on chalk, and only very rarely on chalky loam, so that it behaved practically as a calcifuge. In Bedfordshire, in 1910, it was not often seen, but it was associated with several kinds of soil without showing much preference. This at once shows how the difference may have arisen between Long's and the writer's observations on this species, and also affords an indication that if more data were forthcoming many of the other differences would be modified or eliminated.

TABLE OF WEEDS REFERRED TO IN CHAPTER IX (*Exclusive of Weeds Associated with Peat*).

Latin Name.	English Name.	Soil.	Table.	Page.
Agropyron repens	Couch-grass	All soils; prefers heavier land	V	136
Agrostis spp.	Bent grass	All soils	I	126
Alchemilla arvensis	Lady's mantle	All soils; less on chalky land	III	131
Alopecurus agrestis	Black bent	Characteristic of heavy land	IV	134
Anagallis arvensis	Scarlet pimpernel	All soils; prefers chalky land	VIII	148
Anthemis arvensis	Corn chamomile	All soils; less on heavy land	II	129
Anthemis cotula	Stinking mayweed	Characteristic of heavy land	IV	134
Arenaria serpyllifolia	Thyme-leaved sandwort	All soils; less on heavy land	II	129
Atriplex patula	Orache	All soils; prefers heavier land	V	136
Bartsia odontites	Red bartsia	All soils; prefers chalky land	VIII	148
Brassica alba	White mustard	Characteristic of chalky soils	VII	146
Brassica sinapis	Charlock	All soils; prefers heavier land	V	136
Capsella bursa-pastoris	Shepherd's purse	All soils	I	126
Carduus nutans	Musk thistle	All soils; prefers chalky and light land	IX	150
Centaurea nigra	Hardhead	Characteristic of chalky soils	VII	146
Centaurea scabiosa	Greater knapweed	All soils; prefers chalky land	VIII	148
Cerastium vulgatum	Mouse-ear chickweed	All soils	I	126
Chenopodium album	Fat hen	All soils	I	126
Chrysanthemum segetum	Corn marigold	Characteristic of sand and very light soil deficient in lime	VI	141
Cirsium arvense	Creeping thistle	All soils	I	126
Convolvulus arvensis	Bindweed	All soils; prefers heavier land	V	136
Daucus carota	Wild carrot	All soils; prefers chalky land	VIII	148
Equisetum arvense	Horsetail	All soils; common on heavy land	V	136
Euphorbia exigua	Dwarf spurge	All soils; prefers heavier land	V	136
Euphorbia helioscopia	Sun spurge	All soils; less on heavy land	II	129
Euphorbia peplus	Petty spurge	All soils	I	126
Filago germanica	Cudweed	All soils; prefers chalky and light land	IX	150
Fumaria officinalis	Fumitory	All soils; prefers chalky land	VIII	148

TABLE OF WEEDS REFERRED TO IN CHAPTER IX (*Exclusive of Weeds Associated with Peat*)—*cont.*

Latin Name.	English Name.	Soil.	Table.	Page.
Galium aparine	Cleavers	All soils; prefers heavier land	V	136
Geranium dissectum	Cut-leaved geranium	Characteristic of heavy land	IV	134
Geranium molle	Soft crane's-bill	All soils; less on heavy land	II	129
Geranium pusillum	Small crane's-bill	All soils; prefers chalky and light land	IX	150
Gnaphalium uliginosum	Marsh cudweed	Characteristic of sand and very light soil deficient in lime	VI	141
Heracleum sphondylium	Hogweed	All soils; prefers chalky land	VIII	148
Lamium amplexicaule	Henbit	All soils; prefers chalky and light land	IX	150
Lamium purpureum	Red deadnettle	All soils; less on chalky land	III	131
Lapsana communis	Nipplewort	All soils; prefers heavier land	V	136
Legousia hybrida	Corn campanula	All soils; prefers chalky and light land	IX	150
Linaria spuria	Round-leaved toadflax	All soils; prefers chalky land	VIII	148
Linaria vulgaris	Yellow toadflax	Characteristic of chalky soils	VII	146
Lithospermum arvense	Corn gromwell	Characteristic of chalky soils	VII	146
Lychnis githago	Corn cockle	All soils	I	126
Lychnis vespertina	White campion	All soils; prefers chalky land	VIII	148
Lycopsis arvensis	Field alkanet	All soils; prefers chalky and light land	IX	150
Matricaria chamomilla	Wild chamomile	All soils; less on chalky land	III	131
Matricaria inodora	Scentless mayweed	All soils; less on chalky land	III	131
Mentha arvensis	Corn mint	All soils; prefers heavier land	V	136
Myosotis arvensis	Field forget-me-not	All soils	I	126
Papaver argemone	Pale poppy	All soils; less on chalky land	III	131
Papaver rhœas	Red poppy	All soils; less on heavy land	II	129
Plantago lanceolata	Ribwort plantain	All soils	I	126
Plantago major	Greater plantain	All soils; common on heavy land	V	136
Plantago media	Hoary plantain	Characteristic of heavy land	IV	134
Poa annua	Annual meadow-grass	All soils; less on chalky land	III	131
Polygonum aviculare	Knotgrass	All soils	I	126
Polygonum convolvulus	Black bindweed	All soils	I	126
Polygonum persecaria	Willowweed	All soils; less on chalky land	III	131

TABLE OF WEEDS REFERRED TO IN CHAPTER IX (*Exclusive of Weeds Associated with Peat*)—*cont.*

Latin Name.	English Name.	Soil.	Table.	Page.
Potentilla anserina	Silverweed	All soils	I	126
Ranunculus acris	Tall buttercup	All soils; prefers chalky land	VIII	148
Ranunculus arvensis	Corn buttercup	Characteristic of heavy land	IV	134
Ranunculus repens	Creeping buttercup	All soils	I	126
Raphanus raphanistrum	Wild radish	All soils	I	126
Reseda lutea	Wild mignonette	Characteristic of chalky soils	VII	146
Rumex acetosella	Sheep's sorrel	Characteristic of sand and very light soil deficient in lime	VI	141
Rumex crispus	Curled dock	All soils	I	126
Rumex obtusifolius	Broad dock	All soils; less on chalky land	III	131
Scabiosa arvensis	Field scabious	All soils; prefers chalky land	VIII	148
Scandix pecten	Shepherd's needle	All soils	I	126
Scleranthus annuus	Annual knawel	Characteristic of sand and very light soil deficient in lime	VI	141
Senebiera coronopus	Swinecress	All soils; common on heavy land	V	136
Senecio vulgaris	Groundsel	All soils	I	126
Sheradia arvensis	Field madder	All soils	I	126
Silene inflata	Bladder campion	All soils; prefers chalky land	VIII	148
Sonchus arvensis	Corn sowthistle	All soils; common on heavy land	V	136
Spergula arvensis	Spurry	Characteristic of sand and very light soil deficient in lime	VI	141
Stellaria media	Chickweed	All soils	I	126
Taraxacum vulgare	Dandelion	All soils; prefers chalky land	VIII	148
Tussilago farfara	Coltsfoot	All soils; prefers heavier land	V	136
Urtica urens	Small nettle	Characteristic of sand and very light soil deficient in lime	VI	141
Valerianella olitoria	Lamb's lettuce	Characteristic of chalky soils	VII	146
Veronica agrestis	Field speedwell	All soils	I	126
Veronica arvensis	Wall speedwell	All soils; less on chalky land	III	131
Veronica hederæfolia	Ivy-leaved speedwell	All soils; less on chalky land	III	131
Veronica serpyllifolia	Thyme-leaved speedwell	All soils; prefers chalky and light land	IX	150
Veronica tournefortii	Large field speedwell	All soils; prefers heavier land	V	136
Viola tricolor	Field pansy	All soils; prefers chalky land	VIII	148

CHAPTER X.

ARABLE WEEDS. ASSOCIATION WITH CROPS.

It has already been pointed out that one of the chief factors in determining the abundance or scarcity of a particular weed is the degree of competition it is able to withstand successfully, and furthermore, that the above-ground struggle for light is as important as the underground struggle for food and water. This being the case, the habit of growth of the various crops and the differing systems under which they are cultivated have a great deal to do with determining the composition of the weed flora. A normal crop of clover or temporary grass grows strongly and completely covers the ground, so that it is impossible for the majority of weeds to live at all except in bare patches where the crop has failed. Consequently very few of the ordinary local farm weeds are to be found among such a crop, unless the latter has come so badly that the ground is not covered and the weeds have an opportunity to live. On the other hand, there are a few weeds, like geranium, campion, and field madder, which are specially fitted to grow among a smothering crop, and these plants are generally to be found in the clover. The seeds are carried with the crop seeds and the weeds flourish among the crops, but they are so impatient of cultivation, or are so unable to withstand the open situation among cereals and roots, that very few of them survive when once the clover or grass has been removed from the ground.

Amongst cereal crops matters are quite otherwise. The crop plants grow in regular rows, well spaced out, and for a long period during early growth the plants are small and offer comparatively little competition to the weeds except in the rows in which they are sown. This is most favourable for the weeds, and if it were not for occasional cultivation the crop would have a very poor chance as it would become choked out or smothered by the weeds. Indeed, this is occasionally seen to happen, especially on light sandy land on

which, owing to a deficiency of lime in the soil, spurry is rampant. Such soils are sometimes loaded with buried spurry seed, and if the season be favourable to the germination and early growth of the plant it comes up strongly in such enormous quantities that no amount of cultivation, short of hand pulling at great expense, is able to remove sufficient of it to prevent it from becoming a most serious competitor of the crop. Even when it is possible to make a fair clearance some parts of the fields always seem to defy all efforts and grow crops of spurry instead of corn, thus reducing the profitable crop and causing a considerable monetary loss. On less acid soils of light types the poppy behaves in much the same way, but as this weed grows upright instead of sprawling over the ground it gives the crop a slightly better chance. The time at which the crop is sown and the nature of the growing season have a great effect upon the variety and abundance of weeds. Autumn sown wheat germinates, makes a little growth, and then waits until the following spring before it makes much headway. Many of the weed seeds germinate very freely in the autumn, seedlings grow up among the wheat and are well established by the spring. Cultivating between the drills removes many of them at that time, but a very considerable proportion remain to come into competition with the wheat. Charlock, for instance, holds its own in the drill, and it is quite usual to see fields of wheat flaming yellow with charlock in the spring sunshine. If the wheat gets a good start it will grow so rapidly that it overtops the weeds, and by depriving them of light keep them under to a great extent. If the season be unfavourable, however, wheat and weeds have to continue in competition, with the result that the wheat plants suffer from overcrowding and the crop is short.

It is much more easy to cope with the weeds when corn is sown in the spring. The land is laid up roughly in the autumn and multitudes of weed seeds germinate and begin to flourish, only to be turned under and destroyed when the land is ploughed in the spring previous to sowing. If two or three ploughings are given before sowing, more and more of the weed seeds are thus put out of the way of doing harm. When the crop is sown it grows straight away after the seedlings are up, and unless the weather is exceptionally droughty there is no check to development. The weed seeds begin to germinate as well but they have little chance among the crop, as before they get a good foothold the crop plants are so lusty that the weeds are injured by competition in a very early stage of

growth, and never have a chance to grow big enough to do any damage. Thus it happens that good strong crops of spring-sown wheat, oats, and barley are remarkably free from weeds during the growing season. In July and August the ground below the plant is clean, with only an occasional sickly weed struggling for existence here and there. It is sometimes said that the best way to get rid of weeds is to keep the crops growing well and strongly, enabling them to carry out the work of eradication themselves without much artificial aid. If the season be unfavourable and a long drought prevents the corn from growing away strongly the weeds have a much better chance. Some of them can stand drought well, and as at such times they often grow more rapidly than the crop they are able to come into strong competition.

Root crops are kept so well cultivated that there is no definite evidence to show how they would behave towards weeds if they were left to themselves. The ground is very well prepared beforehand and the seeds are sown comparatively late in the season, with the result that large numbers of the weed seeds have started into growth and been destroyed before the crop is sown. The constant use of the hoe during growth does not give the weeds any chance, and it is for this reason that roots are considered to be such valuable "cleaning crops".

This general association of weeds with crops is obvious, but detailed investigation shows that a much closer connection exists between certain crops and particular species of weeds. Whilst most weeds of any importance are to be found associated to some extent with every crop, yet many of them are specially encouraged or discouraged by one crop or another.

Comparatively few weeds are equally prevalent among all crops and these few comprise some of the most abundant and widely distributed plants. The others all have some special relation to the crops, either of aversion or sympathy. In considering this question it is generally of little use to take into account those weeds which occur very seldom, as the data are not often sufficiently reliable to base conclusions upon. In a few cases, however, this rule has been departed from, where the indications of association are particularly marked.

An examination of the lists of the percentage of frequency of the chief weeds among the different classes of crops shows that roots, seeds, peas, and beans have the most direct influence upon the weed flora. The weeds that are encouraged or discouraged by these crops divide up into distinct classes with

hardly any overlapping, so that a plant which appears under one heading is very seldom found under another. The cereals, however, do not act quite in the same way. As a whole they form an indifferent body of crops, because hardly any weeds are either specially associated with them or usually absent from among them. Some differences are evident between the cereals, weeds that are common among wheat being often scarce among barley, etc., but the division is not so clear as with the other classes of crops. For this reason a consideration of the association of weeds with cereals is postponed for a time, because all the chief weeds can be classified under other headings.

For this purpose arable weeds may be summarised thus :—

(1) Weeds that are found as often among one crop as another.

(2) (*a*) Weeds specially associated with root crops.

(*b*) Weeds discouraged by root crops.

(3) (*a*) (*α*) Weeds specially associated with temporary grass or clover ("seeds").

(*β*) Weeds specially associated with temporary grass or clover and wheat crops.

(*b*) Weeds discouraged by temporary grass or clover ("seeds").

(4) (*a*) Weeds specially associated with peas and beans.

(*b*) Weeds discouraged by peas and beans.

1. *Weeds that are Found as often Among one Crop as Another.*

TABLE X.—WEEDS THAT ARE FOUND AS OFTEN AMONG ONE CROP AS ANOTHER.

Latin Name.	English Name.	Percentage of Frequency (= Number of Times Seen per 100 Fields).						
		All Crops.	Wheat.	Barley.	Oats.	Roots.	Seeds.	Peas and Beans.
Brassica sinapis	Charlock	34	37	42	50	26	25	34
Capsella bursa-pastoris	Shepherd's purse	30	38	30	33	27	28	31
Cirsium arvense	Creeping thistle	73	65	74	67	75	63	69
Convolvulus arvensis	Bindweed	54	56	67	52	51	43	45
Linaria vulgaris	Toadflax	6	5	7	5	4	8	3
Rumex acetosella	Sheep's sorrel	9	6	4	15	7	10	7
Rumex crispus	Curled dock	41	50	39	44	30	41	48
Senecio vulgaris	Groundsel	33	33	26	37	32	33	43
Sonchus arvensis	Corn sow-thistle	27	26	34	24	17	37	34
Veronica agrestis	Field speedwell	19	23	28	24	13	13	22

The plants in Table X are commonly associated with every type of crop, and some of them are among the most frequent and abundant weeds. A few of them, however, are more specially favoured by certain crops, this being shown by their relative abundance and the number of times that they usurp the position of dominant weeds. Charlock (*Brassica sinapis*) is often dominant among all crops, but particularly in wheat and oats. Field bindweed (*Convolvulus arvensis*) dominates very frequently, specially among barley and on fallow land. Creeping thistle (*Cirsium arvense*), on the other hand, is abundantly dominant among all crops, if allowed, but it is rather less favoured by wheat, oats and seeds. The rest of the weeds in this class are not often present in great quantity, partly because they are so steadily eradicated when seen that they do not have a fair chance. Sheep's sorrel (*Rumex acetosella*) and groundsel (*Senecio vulgaris*) flourish best among seeds; corn sow-thistle (*Sonchus arvensis*) is seldom very plentiful except with barley; field speedwell (*Veronica agrestis*) is sometimes abundant among oats and peas and beans. Some of the weeds, again, are frequently present in very small quantity although they are so wide spread. Shepherd's purse (*Capsella bursa-pastoris*) is often scarce among all crops, yellow toadflax (*Linaria vulgaris*) is rarely or never dominant, while the curled dock (*Rumex crispus*) is so persistently attacked that it is rarely allowed to take first place among the weeds and is instead often reduced to a position of scarcity.

It is obvious that most of the weeds that are well distributed among all crops are specially adapted for the purpose, being able to tide over adverse circumstances induced by the habit of any crop or by any particular method of cultivation. Charlock, shepherd's purse, curled dock and field speedwell produce large quantities of seeds which do not all germinate at the same time. Some of these seeds start into growth and the seedlings are often destroyed by cultivation, but another batch of seeds is waiting its turn, and usually weeds of this description baffle the farmer unless he is particularly alert. Creeping thistle and bindweed have creeping underground stems which possess an amazing power of retaining their vitality and growing under any circumstances, so that the type of crop does not affect them greatly. Corn sow-thistle and groundsel are provided with plumed fruits, and the seeds may not only remain buried in the soil from one year to another, but a fresh supply may be constantly

brought by the wind, throughout the year in the case of groundsel, and in late summer and early autumn in the case of corn sow-thistle.

A comparison of Table I with Table X shows that very few weeds are indifferent both in regard to the soil they occupy and the crops amongst which they grow, shepherd's purse, creeping thistle, curled dock, groundsel, and field speedwell being the only ones in this category. The other weeds that are found as often in one crop as in another are more particular as to soil, so that in their case the nature of the soil, and not that of the crop, determines the distribution. On the other hand, most of the weeds that have no preference as to soil are greatly influenced by the nature of the crop, and therefore in this case the crop, and not the soil, is the determining factor in distribution. This means that the nature of the soil and the type of crop act independently on the weed flora and that the weeds themselves respond in various ways to the action of the two factors which are necessarily at work at one and the same time.

2. (*a*) *Weeds Specially Associated with Root Crops.*—A careful consideration of all the results does not reveal a single weed that has a particular association with root crops. Roots are sown quite late in the season, which gives the opportunity of cleaning the land well beforehand. During the growing season the cultivator and hoe are kept at work, so that only the most persistent and ubiquitous weeds are able to maintain a footing.

The constant cultivation among root crops tends to make a great clearance of the weeds, as under conditions of good farming comparatively few plants are allowed to attain any size. In this way the abundance of the weeds is greatly reduced, but most of the more common species are to be found among the roots throughout the season. This is because the stores of seeds or underground parts in the soil are so great that the very cultivation which clears away one crop of seedlings prepares the soil for another crop to germinate or start into growth. Some weeds, however, seem to resent the interference and are often absent from roots in fields that they frequent when other crops occupy the ground.

(*b*) *Weeds Discouraged by Root Crops.*

TABLE XI.—WEEDS DISCOURAGED BY ROOT CROPS.

Latin Name.	English Name.	Percentage of Frequency (= Number of Times Seen per 100 Fields).						
		All Crops.	Wheat.	Barley.	Oats	Roots.	Seeds.	Peas and Beans.
Anagallis arvensis	Pimpernel	18	21	22	22	12	19	17
Bartsia odontites	Red bartsia	7	14	2	5	—	8	7
Brassica alba	White mustard	7	7	8	7	2	7	7
Cerastium vulgatum	Mouse-ear chickweed	7	12	2	5	1	22	5
Euphorbia exigua	Dwarf spurge	11	13	18	12	5	12	10
Lychnis vespertina	Campion	17	12	19	21	9	37	14
Papaver rhœas	Common red poppy	33	48	38	34	13	43	26
Plantago major	Greater plantain	19	22	24	28	8	23	22
Ranunculus repens	Creeping buttercup	13	17	9	13	4	23	19
Tussilago farfara	Coltsfoot	20	27	19	24	12	17	26
Viola tricolor	Pansy	22	25	22	19	13	35	22
Matricaria inodora	Scentless mayweed	16	24	13	21	8	11	29
Scandix pecten	Shepherd's needle	12	22	18	15	3	5	10

Very few of those weeds thus discouraged are present in large quantities under any circumstances, and this may account for the comparative ease with which they are reduced among roots. Pimpernel (*Anagallis arvensis*), mouse-ear chickweed (*Cerastium vulgatum*), and dwarf spurge (*Euphorbia exigua*) have never been found dominant anywhere, while greater plantain (*Plantago major*), creeping buttercup (*Ranunculus repens*), field pansy (*Viola tricolor*), campion (*Lychnis vespertina*) have each one record of dominance to their credit among other crops, but never one among roots. The red poppy (*Papaver rhœas*), however, provides a single example of a weed that is most abundant in some districts, and yet often absent from the root crops in these very areas. The soil contains numberless seeds, but under these particular conditions of cultivation the poppies make little headway. This is well shown by the fact that the red poppy was only once found dominant amongst roots, when among other crops in the same district it dominated no less than 92 times. This fact in itself shows how bitterly the poppy resents the interference of cultivation. White mustard (*Brassica alba*) behaves in a similar way, though the discrepancy

is less marked—with two instances of dominance among roots and twenty-three elsewhere. Coltsfoot (*Tussilago farfara*) is very considerably affected, but makes a better fight for its position than any other weed in the group, managing to become dominant as often in proportion among roots as among other crops.

(3) (*a*) *Weeds Specially Associated with Temporary Grass and Clover* ("*Seeds*") *or with* "*Seeds*" *and Wheat Crops.*

These two classes of weeds are very clearly marked out. Two distinct factors are evident in this case, which work together and help to make the flora of "seeds" crops more distinctive than any other. The first factor is that "seeds" form essentially a smothering crop. They are sown very thickly, and from an early date they spread out and cover the ground closely, in contrast to the cereals, which grow fairly upright, and to roots, in which open spaces are left for a long period of time. Consequently, any weeds that dislike competition stand a poor chance among seeds, and only those can flourish whose habit permits them to enter into effective competition with the crop. Some, but not all, of the "seeds" weeds are equally abundant among wheat. The second factor is that the seed of clover, trefoil, medick, etc., is so small that effective cleaning is difficult, and large numbers of weed seeds may therefore be introduced when the crop is sown. These introduced weeds are a class apart, for they flourish among their harbouring crop, but do not persist further on in the rotation in any quantity. Apparently cultivation is obnoxious to them, and the great majority quietly disappear when once the ley is ploughed up. The weeds that are common among both seeds and wheat are also usually introduced with the seed crop, but they seem to be able to hold their ground for a season in the wheat that so commonly follows a clover ley. After this, however, they tend to disappear like the rest. The two sets of weeds are as follows :—

(*a*) *Weeds Specially Associated with Temporary Grass or Clover* ("*Seeds*").

TABLE XII.—WEEDS SPECIALLY ASSOCIATED WITH TEMPORARY GRASS OR CLOVER.

Latin Name.	English Name.	Percentage of Frequency (= Number of Times Seen per 100 Fields).						
		All Crops.	Wheat.	Barley.	Oats.	Roots.	Seeds.	Peas and Beans.
Anthemis arvensis	Corn chamomile	3	4	2	2	0·5	12	—
Daucus carota	Wild carrot	3	2	5	1	1	17	5
Geranium molle	Dove's-foot crane's-bill	8	5	4	0·5	5	31	2
Lychnis vespertina	Campion	17	12	19	21	9	37	14
Plantago lanceolata	Ribwort plantain	9	7	2	4	2	41	9
Sheradia arvensis	Field madder	7	8	1	5	5	31	5
Viola tricolor	Pansy	22	25	22	19	13	35	22

Although these weeds are so usually found among seeds they are very seldom dominant, probably because the smothering nature of the crop prevents any other plant from usurping too predominant a position. Most of the plants are very closely connected with "seeds" crops only, but campion (*Lychnis vespertina*) and field pansy (*Viola tricolor*) are common among others, with a decided preference for "seeds". Both these weeds are introduced with "seeds," and they are able to hold their own throughout the rotation, though never present in any quantity. Campion (*Lychnis vespertina*) is a great contrast to its companion, as its habit is so utterly different. Most of this section are small low growing plants which spread out close to the surface of the ground in a rosette form, so that no other plant is able to crowd into the ground occupied by the spreading of the weed. Campion, however, is a bold, strong grower, and shoots up over the head of the crop to revel in the freedom of the upper air.

In addition to the weeds given in Table XII a number of others that occur comparatively seldom are chiefly associated with "seeds" crops. These all behave in the same way, and disappear with the succeeding crop in the rotation.

The chief of these are:—

Carduus nutans . . Musk thistle
Cirsium lanceolatum . . Spear thistle
Filago germanica . . Cudweed
Geranium dissectum . . Cut-leaved geranium
Geranium pusillum . . Small-flowered crane's-bill
Reseda lutea . . . Wild mignonette (equally common among barley).

(β) *Weeds Specially Associated with Wheat and Temporary Grass and Clover* ("*Seeds*").

TABLE XIII.—WEEDS SPECIALLY ASSOCIATED WITH WHEAT AND TEMPORARY GRASS AND CLOVER.

Latin Name.	English Name.	Percentage of Frequency (= Number of Times Seen per 100 Fields).						
		All Crops.	Wheat.	Barley.	Oats.	Roots.	Seeds.	Peas and Beans.
Alchemilla arvensis .	Lady's mantle . .	9	23	1	5	0·5	16	2
Arenaria serpyllifolia	Thyme-leaved sandwort	10	13	4	4	4	32	5
Cerastium vulgatum .	Mouse-ear chickweed .	7	12	2	5	1	22	5
Myosotis arvensis .	Field forget-me-not .	15	25	7	12	7	33	19
Veronica arvensis .	Wall speedwell . .	·7	20	1	4	0·5	10	7

These weeds resemble the others associated with "seeds" crops in that they are seldom or never dominant. Most of them are so small and inconspicuous that care has to be taken in field work to give them their due weight of importance, as it is easy to under-estimate the quantity present. Sandwort (*Arenaria serpyllifolia*), mouse-ear chickweed (*Cerastium vulgatum*), and forget-me-not (*Myosotis arvensis*) occur more frequently among seeds than among wheat, whereas lady's mantle (*Alchemilla arvensis*) and wall speedwell (*Veronica arvensis*) exhibit a greater preference for wheat. All of them are relatively seldom seen among any other crops.

(*b*) *Weeds Discouraged by "Seeds" Crops.*

It has already been mentioned that the peculiar habit of "seeds" crops is detrimental to the growth of many weeds. Some of the commonest and most abundant farm weeds, including several that are utterly indifferent to the nature of the soil they frequent, cannot endure the close competition of "seeds," and refuse to grow among them. The seeds and underground parts of the weeds, perhaps after making a few futile efforts to establish a position, simply remain dormant in the soil until such time as the antagonistic crop is removed and more favourable conditions supervene. Then, little the worse for their waiting period, they reassert themselves among the later crops in the rotation.

TABLE XIV.—WEEDS DISCOURAGED BY "SEEDS" CROPS.

Latin Name.	English Name.	Percentage of Frequency (= Number of Times Seen per 100 Fields).						
		All Crops.	Wheat.	Barley.	Oats.	Roots.	Seeds.	Peas and Beans.
Agropyron repens	Couch-grass	15	18	5	12	25	4	24
Agrostis spp.	Bent-grass	22	33	10	18	28	14	29
Atriplex patula	Orache	15	16	9	18	23	3	16
Chenopodium album	Fat hen	44	32	61	48	60	17	48
Equisetum arvense	Horsetail	24	29	26	26	24	14	31
Galium aparine	Goosegrass	25	37	21	21	23	15	38
Lamium purpureum	Red deadnettle	4	3	2	3	6	1	3
Mentha arvensis	Corn mint	14	17	16	12	14	8	17
Poa annua	Annual meadow-grass	17	35	10	14	14	8	17
Polygonum aviculare	Knotgrass	56	62	58	63	64	21	62
Polygonum convolvulus	Black bindweed	49	48	64	56	63	20	45
Polygonum persecaria	Willow-weed	12	10	12	18	15	3	10
Spergula arvensis	Spurry	19	13	17	34	23	7	24
Stellaria media	Chickweed	45	52	45	41	59	18	50
Veronica hederæfolia	Ivy-leaved speedwell	18	20	22	20	21	2	29
Veronica tournefortii	Large field speedwell	29	31	19	22	36	14	40

All the weeds classified in the above table are seriously handicapped in the presence of a "seeds" crop, but some are much more affected by the competition than others. Bent grass (*Agrostis spp.*), horsetail (*Equisetum arvense*), goosegrass (*Galium aparine*), corn mint (*Mentha arvensis*), and large field speedwell (*Veronica tournefortii*) are among those that are less influenced. Orache (*Atriplex patula*), knotgrass (*Polygonum aviculare*), willow-weed (*Polygonum persecaria*), and especially ivy-leaved speedwell (*Veronica hederæfolia*) are more seriously affected, as their frequency is far less than half that among all crops. Couch-grass (*Agropyron repens*) appears to come in this latter group, but it is quite conceivable that on some occasions it was overlooked, as it is difficult to distinguish it from some of the grasses which have a legitimate place in "seeds" crops.

The majority of these weeds are rarely present in any quantity, and few of them are ever dominant. Orache, goosegrass, red dead nettle, corn mint, willow-weed, chickweed, couch-grass and ivy-leaved speedwell were never observed to be dominant among this crop throughout the course of the investigation, though many of them were frequently the chief weeds among other crops. Bent-grass, fat hen, horsetail,

annual meadow-grass, knotgrass, black bindweed, spurry, and large field speedwell were very occasionally found dominant, but much less frequently than they were in other cases.

4. (*a*) *Weeds Specially Associated with Peas and Beans.*

In spite of the difference in soil conditions under which peas and beans are grown they carry a very similar weed flora. These crops are different in habit from any others grown on a farm; the individual plants are very strong growing, but in the earlier stages they do not cover the ground to the same extent as a young, healthy crop of seeds. Later on in life peas and beans are as efficient smother crops as are seeds, but the diversity of their earlier history influences the weed flora considerably, so that the plants that are encouraged or injured by the two classes of crops are entirely different. Peas and beans are regarded as being the dirtiest crops on a farm, because the weeds have a fair opportunity of establishing themselves while the crop is young; little cultivation can be carried out for fear of damaging the peas and beans, and many of the weeds thus become strong enough to withstand the later smothering action. Only two weeds, black bent and corn buttercup, receive special encouragement from this type of crop, and both these are correspondingly prevalent among wheat, and are discussed under that heading also.

TABLE XV.—WEEDS SPECIALLY ASSOCIATED WITH PEAS AND BEANS.

Latin Name.	English Name.	Percentage of Frequency (= Number of Times Seen per 100 Fields).						
		All Crops.	Wheat.	Barley.	Oats.	Roots.	Seeds.	Peas and Beans.
Alopecurus agrestis .	Black bent .	5	9	2	4	2	3	21
Ranunculus arvensis .	Corn buttercup .	4	12	2	3	1	1	7

Black bent (*Alopecurus agrestis*) is profoundly influenced by cultivation. If once it gets a fair start and is not interfered with too much it can hold its own well, but if badly disturbed in the early stages it has very little chance. For this reason it is not usually a serious pest, ordinary rotation farming keeping it in check. Peas and beans afford a most congenial shelter for it, the comparative openness of situation at the outset and the subsequent lack of cultivation providing

the very conditions it delights in, so that the black bent is able to make good growth before the crop gets too thick, and is then strong enough to grow up with the peas and beans and to maintain its position.

(*b*) *Weeds Discouraged by Peas and Beans.*

TABLE XVI.—WEEDS DISCOURAGED BY PEAS AND BEANS.

Latin Name.	English Name.	Percentage of Frequency (= Number of Times Seen per 100 Fields).						
		All Crops.	Wheat.	Barley.	Oats.	Roots.	Seeds.	Peas and Beans.
Centaurea nigra .	Hardhead . .	5	3	9	6	3	6	—
Euphorbia helioscopia	Sun spurge .	6	6	13	6	6	5	—
Potentilla anserina .	Silverweed .	10	12	12	10	8	14	2
Scabiosa arvensis .	Field scabious .	11	12	15	13	6	14	3
Silene inflata . .	Bladder campion	9	9	16	8	4	11	3
Taraxacum vulgare .	Dandelion . .	9	10	9	10	3	15	3
Fumaria officinalis .	Fumitory . .	21	19	24	26	25	14	12

This is not a very well-marked class of plants. With the exception of fumitory (*Fumaria officinalis*) few of the weeds are very frequent or plentiful, and several of them are adversely affected by other crops as well as by peas and beans.

Hardhead (*Centaurea nigra*) and sun spurge (*Euphorbia helioscopia*) are the most influenced by this crop, as they failed to appear among it on any occasion, though they were well distributed through all other crops. Neither of these weeds is ever dominant, and sun spurge is frequently scarce, so it is easy to understand why they disappear rapidly under unfavourable circumstances. Silverweed (*Potentilla anserina*) is nearly as intolerant as the last two described, for it was only twice seen among peas or beans.

Field scabious (*Scabiosa arvensis*), bladder campion (*Silene inflata*) and dandelion (*Taraxacum vulgare*) have almost as great an objection to root crops as to peas and beans. Although they occur rather frequently they are seldom or never dominant, and dandelion is often scarce.

Fumitory (*Fumaria officinalis*) is abundant and frequent. It is an early plant and much of it has died away by June and July, so that quite possibly it is really more abundant than the records show, as the observations made later in the year

may have often failed to take adequate account of the species. It does not show a very pronounced objection to growing among any crop, but "seeds," peas, and beans reduce it by about one-half. The quantity occurring is reduced even more than the frequency, for although fumitory is very often dominant among most crops at certain periods of the year, it was only once observed dominant among peas and beans. Usually this plant gives very little trouble, as it is ephemeral and the quantity is not often serious even when it is the chief weed in a field.

Association of Weeds with Cereal Crops.

The cereals form a group of plants that collectively has less direct influence upon the weed flora than any of the other types of crop. The drills are placed some distance apart and the habit of the young plant is such that the weed seeds have a good opportunity of starting into growth under favourable conditions. Later cultivation, where this is done, destroys many of the weeds, but those that are present along the drills themselves escape destruction. Consequently, the weed flora of cereal crops remains fairly representative, except where the crop is so exceptionally heavy that all undergrowth is smothered out. Arable weeds occur with almost equal frequency among cereals and among all crops added together, and in most cases the figures practically coincide. A few weeds are rather more frequent among cereals, as is shown in the table on opposite page, but even with these the differences are not great. Only two weeds, ribwort plantain (*Plantago lanceolata*) and dove's-foot crane's-bill (*Geranium molle*), are less frequent, but this is not due to discouragement by the cereal crop, but to their introduction in large quantities in the seeds of temporary leys.

The weed floras associated with the individual cereal crops show certain variations, but these differences are not at all clearly marked. Every weed of any importance is found amongst all the cereals, but some are more particularly encouraged or discouraged by one or other of them. Only two weeds are so adversely affected by any cereal crop that they practically disappear—i.e. lady's mantle (*Alchemilla arvensis*) and wall speedwell (*Veronica arvensis*), which are hardly ever seen among barley. In all other cases the association is less definite. Some of the weeds can be grouped in two distinct ways, according as they are more particularly associated with

WEEDS THAT ARE MORE FREQUENT IN CEREAL CROPS.

Latin Name.	English Name.	Percentage of Frequency (= Number of Times Seen per 100 Fields).	
		All Crops.	Cereal Crops.
Anagallis arvensis	Scarlet pimpernel	18	22
Brassica sinapis	Charlock	34	41
Papaver rhœas	Red poppy	33	41
Plantago major	Greater plantain	19	24
Polygonum convolvulus	Black bindweed	49	56
Scandix pecten	Shepherd's needle	12	19
Veronica agrestis	Field speedwell	19	25
Weeds that are Less Frequent in Cereal Crops.			
Geranium molle	Dove's-foot crane's-bill	7·5	3
Plantago lanceolata	Ribwort plantain	9	5

wheat or are relatively scarce among barley. The two groups, however, are largely identical, indicating that some factor is at work with one crop that is absent from the other. This factor is probably the difference in the time of sowing of the two crops. Wheat in this country is usually sown in the autumn, thus hindering an effective cleaning of the land. Weed seeds germinate and grow up with the corn, and the nature of the crop hinders an effective clearance by later cultivation. Barley, on the other hand, is spring sown, very often after roots. The land is ploughed up and lies fallow throughout the winter, when the weed seeds germinate and make good headway. Further cultivation occurs before the crop is sown, the weed seedlings are destroyed, and even though other dormant seeds may start into growth they have to face far greater competition from the crop, which gets away rapidly and is a much greater competitor to the young seedlings than is the wheat plant to those weeds that germinate in autumn. If all these weeds are cut out, very few are left which show any special connection with particular cereals. In the following table the two groups are put together in so far as they are identical, and the remaining weeds are classified under their separate headings. It may be noted that while spurry (*Spergula arvensis*) and fat hen (*Chenopodium album*) are both discouraged by wheat, the former is specially prevalent among oats and the latter among barley.

Latin Name.	English Name.	Percentage of Frequency (= Number of Times Seen per 100 Fields).		
		All Cereals.	Wheat.	Barley.
Weeds that are Specially Frequent among Wheat and Less Frequent among Barley.				
Agrostis spp.	Bent grass	23	33	10
Alchemilla arvensis	Lady's mantle	11	23	1
Bartsia odontites	Red bartsia	8	14	2
Cerastium vulgatum	Mouse-ear chickweed	7	12	2
Myosotis arvensis	Field forget-me-not	16	25	7
Poa annua	Annual meadow-grass	21	35	10
Ranunculus arvensis	Corn buttercup	6	12	2
Veronica arvensis	Wall speedwell	10	20	1
Weeds Specially Frequent Among Wheat.				
		All Cereals.		Wheat.
Alopecurus agrestis	Black bent	5		9
Arenaria serpyllifolia	Thyme-leaved sandwort	8		13
Galium aparine	Goosegrass	27		37
Weeds Less Frequent Among Wheat.				
Chenopodium album	Fat hen	45		32
Spergula arvensis	Spurry	20		13
Weeds Specially Frequent among Barley.				
		All Cereals.		Barley.
Chenopodium album	Fat hen	45		61
Euphorbia helioscopia	Sun spurge	8		13
Silene inflata	Bladder campion	9		16
Weeds Less Frequent among Barley.				
Agropyron repens	Couch grass	12		5
Matricaria inodora	Scentless mayweed	20		13
Sheradia arvensis	Field madder	5		1
Weeds Specially Frequent among Oats.				
		All Cereals.		Oats.
Rumex acetosella	Sheep's sorrel	8		15
Spergula arvensis	Spurry	20		34
Weeds Less Frequent among Oats.				
Geranium molle	Dove's-foot crane's-bill	3		0·5
Veronica arvensis	Wall speedwell	10		4

CHAPTER XI.

GRASS-LAND WEEDS.

THE consideration of the weeds of grass-land presents a very different problem from that of arable weeds because of the totally different nature of the crop with which the weeds are associated. Arable land crops are, so to speak, alien to their situation and are grown on bare soil, which offers a clear field for the competition of other species that are native to the soil and would carry all before them if they were not hindered by cultivation. On grass-land, on the contrary, the crop consists of an association of plants that are usually themselves native to the soil and that grow in a closely interwoven mat covering the surface of the ground, thus excluding all plants that cannot make headway against keen competition. Then again, on arable land it is only the produce of the sown seed that is of use as a crop, whereas on grass-land it matters little what particular species enter into the composition of the herbage provided that they are not injurious or poisonous and that the feeding value for stock is high. Consequently in many cases it is not possible to draw a sharp distinction between the crop plants and the weeds, as a species that is quite a useful constituent of herbage in one place may be a veritable pest elsewhere. Whether it be mown for hay or grazed, herbage typically consists of a mixture of grasses, leguminous plants, and miscellaneous species from other orders. Each of these groups contains some plants that are most valuable from the farmer's point of view but others that are regarded as of little use or as harmful weeds. The criterion is usually the feeding value of the plant but this varies with circumstances, as it is influenced by soil conditions, climate, and other factors, concerning which our knowledge is very imperfect. For instance, on Romney Marsh[1] adjacent fields are

[1] Hall, A. D., and Russell, E. J. (1911), "A Report on the Agriculture and Soils of Kent, Surrey, and Sussex," p. 60.

sometimes "fatting" and "non-fatting," i.e. while the former is excellent grazing pasture and fattens sheep rapidly the latter is of little use except for carrying store beasts. A complete botanical analysis of the herbage reveals no variation in the species present that would account for such a difference, so that the same combination of plants is far more valuable in the one case than in the other. Some grasses, as Yorkshire fog and tall oat, tend to grow rank and coarse under favourable conditions and are then rightly considered as weeds, but nevertheless the best pastures and meadowland of the highest feeding value usually contain one or both of these grasses, the proportion of Yorkshire fog often being quite appreciable.

On account of this necessary reservation, therefore, a weed of grass-land may be considered to be any plant that is in itself useless or injurious (a mere cumberer of the ground), or any plant that in the case in question is of low feeding value and by its abundance or rank growth tends to crowd out and supplant other species that under the same circumstances would provide far more nourishment to the stock feeding thereon. As high feeding value is more usually associated with certain grasses and leguminous plants than with miscellaneous species, it often happens that the most valuable pastures and meadows are stocked almost entirely with the former while the inferior grass-lands show a large percentage of the latter in the composition of their herbage.[1] As a matter of fact, it is usually fairly easy to decide whether a certain species is to be considered as a weed or as a useful plant on a particular area of grass-land. Various rank and tall-growing plants, as thistles, woodwax, nettles, chervil and docks, do not under any circumstances enter into the legitimate composition of the herbage and are always to be regarded as weeds. Running plants, such as couch-grass (*Agropyron repens*), creeping buttercup (*Ranunculus repens*), bindweed (*Convolvulus arvensis*), and bent grass (*Agrostis spp.*), which tend to cover large areas of ground with their matted stems and roots, do much damage to grass-land, and certain rosette plants that lie very close to the ground, e.g. mouse-ear hawkweed (*Hieracium pilosella*), suffocate all other plants growing under the spread of their leaves. All these must be regarded as pernicious and to be removed whenever possible. Poisonous or injurious plants, such as meadow saffron, purging flax, hemlock, and garlic, are not to be

[1] Armstrong, S. F. (1907), "Botanical and Chemical Composition of the Herbage of Pastures and Meadows," *Jour. Agric. Sci.*, II, pp. 283-304.

tolerated, and come into the weed category. The classification of many other plants, as described above, depends upon circumstances.

Local conditions, often varying within small areas, do much to determine the relative abundance of grass-land weeds. The amount of water in the soil is a most potent factor in this way, and its action is well seen on low-lying fields where the water table approaches the surface of the soil rather nearly, as happens in alluvial areas (cf. Berkeley district, Gloucestershire, and Sedgemoor, Somerset). These fields are often thrown into ridge and furrow, the survivals of old arable cultivation, and in the furrow where water-logging occurs rushes and other moisture-loving plants abound. Up the sides of the ridges the rushes gradually get fewer as the soil becomes slightly drier, and unless the field is abnormally low-lying and damp the tops of the ridges are free from rushes. Coincidently with the dying out of the rushes there is often an incoming of the tall buttercup (*Ranunculus acris*), which likes a considerable degree of moisture but cannot withstand absolute waterlogging, so that the tops of the ridges, though bare of rushes, are often colonised by masses of these buttercups. A further sequence may be observed where the fields are slightly higher and but little waterlogging occurs even in the furrows. Then the rushes get less and eventually die out, the tall buttercup descends from the ridge into the furrow, and is replaced more or less completely on the top of the ridge by the allied bulbous buttercup (*R. bulbosus*), which is even more impatient of an excess of water. The above illustrates what is often seen in the West Country, but with possible variation in the plants concerned it gives a good picture of what may be expected to occur in any locality when excess of water is present. Draining gullies and depressions in grass fields are often colonised by various species of docks. The broad-leaved dock (*Rumex obtusifolius*) tends to congregate in places where the water spreads out to flood the fields, while the sharp dock (*R. conglomeratus*) and the blood-red dock (*R. sanguineus*) frequent the gullies and shady places and the edges of fields.

Where the water supply is particularly abundant, as on peaty soils, the herbage takes on quite a different character from that found in drier situations as the typical grass-land plants are less plentiful, their place being taken by a number of miscellaneous plants usually regarded as weeds of low nutritive value, such as ragged robin, meadowsweet, cotton

grass, creeping jenny, mint, sedge and marsh bedstraw. If still more water is present the change is yet greater, and true water and marsh plants appear, including marsh marigold, arrowhead, lady's smock, watercress, pennywort, and purple loosestrife, in addition to various species of rushes.

A great contrast to the weed flora of damp land is seen in that of well-drained high grass-land. The grasses, instead of being lush and rank, tend to grow small and fine, and such weeds as daisy, dog daisy, yellow rattle, pignut, sorrel, quaker grass and rough brome are often abundant. Poor pastures on dry land are frequently characterised by such weeds as milkwort (*Polygala vulgaris*) hardhead, beaked hawksbeard (*Crepis taraxacifolia*), salad burnet (*Poterium sanguisorba*), thyme, lady's mantle (*Alchemilla vulgaris*), and ragwort, while such worthless grasses as false brome (*Brachypodium pinnatum* and *B. sylvaticum*) and soft brome (*Bromus mollis*) are frequently present.[1]

Although it is not always possible to fix the status of a plant as being useful or useless on grass-land, it may be permissible to make a rough classification as follows :—

A. Plants that must be Regarded as Weeds Under all Circumstances.

(*a*) *Poisonous and Injurious Plants.*

Autumn crocus	(*Colchicum autumnale*).
Bindweed	(*Convolvulus arvensis*).
Buttercup	(*Ranunculus spp.*).
Crow garlic	(*Allium vineale*).
Horsetail	(*Equisetum spp.*).
Huffcaps	(*Aira cæspitosa*).
Purging flax	(*Linum catharticum*).
Ragwort	(*Senecio jacobæa*).
Ramsons	(*Allium ursinum*).
Wild barley	(*Hordeum pratense*).

All the above are fully described in Chapter VII. so no more need be said about them here.

[1] Stapledon, R. G. (1910), "On the Flora of Certain Cotswold Pastures," *Scient. Bull. Roy. Agri. Coll., Cirencester*, No. 2, pp. 29-46.

(*b*) *Coarse Growing Plants that Deteriorate the Quality of the Pasture or Meadow.*

Cat's ear	(*Hypochæris radicata*).
Chervil	(*Anthriscus sylvestris*).
Dog daisy	(*Chrysanthemum leucanthemum*).
Docks	(*Rumex obtusifolius, etc.*).
Hogweed	(*Heracleum sphondylium*).
Nettles	(*Urtica dioica* and *U. urens*).
Rest-harrow	(*Ononis repens*).
Scabious	(*Scabiosa arvensis*).
Thistles	(*Cirsium arvense, C. lanceolatum, Carduus nutans*).
Wild carrot	(*Daucus carota*).
Woodwax	(*Genista tinctoria*).
Yarrow	(*Achillea millefolium*).

A few weeds in this class, notably thistles, nettles, and hogweed, have a certain nutritive value and are turned to account when cut down, and some classes of stock will eat them when dried.

(*c*) *Grasses and Plants of Low Feeding Value.*

False brome	(*Brachypodium sylvaticum and B. pinnatum*).
Soft brome	(*Bromus mollis*).
Quaker grass	(*Briza media*).
Rush	(*Juncus spp.*).
Sedge	(*Carex spp.*).

Quaker grass is usually a sign of very poor land and can be eradicated by manurial improvement (Fig. 40). The other two grasses, when circumstances are favourable, tend to overrun the pastures to the exclusion of species of greater feeding value.

(*d*) *Parasitic Weeds.*

Dodder	(*Cuscuta spp.*).
Eyebright	(*Euphrasia officinalis*).
Lousewort	(*Pedicularis palustris*).
Yellow rattle	(*Rhinanthus crista-galli*).

See Chapter VI.

B. Plants that are Considered to Possess a Certain Feeding Value but are Regarded as Weeds if they are Present in too Great Quantity or grow too Luxuriantly.

Bent grass	(*Agrostis spp.*).
Couch-grass	(*Agropyron repens*).
Dandelion	(*Taraxacum vulgare*).
Hardhead	(*Centaurea nigra*).
Sheep's sorrel	(*Rumex acetosella*).
Silverweed	(*Potentilla anserina*).
Sorrel	(*Rumex acetosa*).
Yorkshire fog	(*Holcus lanatus*).

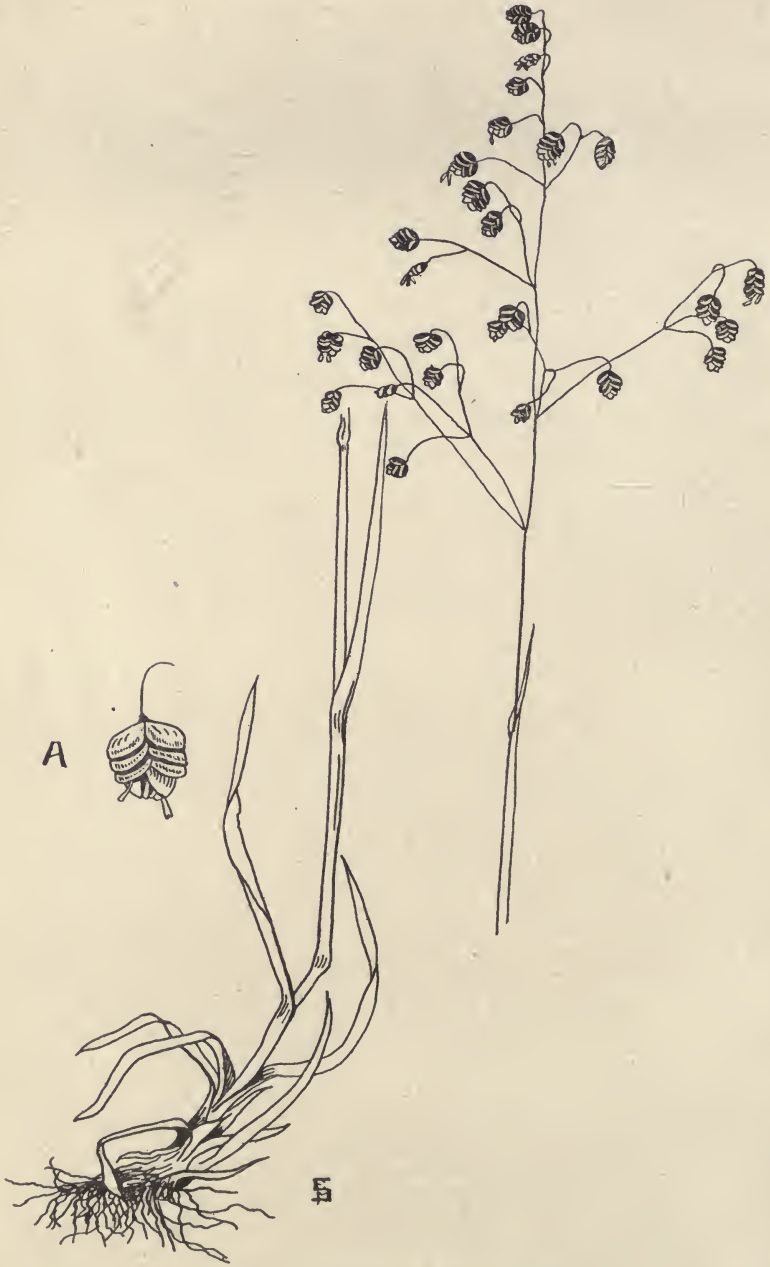


FIG. 40.—QUAKER GRASS (*Briza media*).

C. In addition to the above there are a number of plants that are more or less common denizens of grass-land but which are difficult to classify definitely as weeds. All of them are noxious if they are present in too great abundance, but this is generally because under such circumstances they crowd out and usurp the place of other plants of higher feeding value. Probably most of the plants in this category are of some use as food, but little information is available on this point. In this group are included :—

Cowslip	(*Primula veris*).
Daisy	(*Bellis perennis*).
Germander speedwell	(*Veronica chamædrys*).
Goatsbeard	(*Tragopogon pratensis*).
Greater plantain	(*Plantago major*).
Hoary plantain	(*P. media*).
Ladies' bedstraw	(*Galium verum*).
Mouse-ear chickweed	(*Cerastium vulgatum*).
Mouse-ear hawkweed	(*Hieracium pilosella*).
Pignut	(*Conopodium denudatum*).
Ribwort plantain	(*Plantago lanceolata*).
Salad burnet	(*Poterium sanguisorba*).
Selfheal	(*Prunella vulgaris*).

The above lists must not be taken as in any way exhaustive, though they include the majority of the more common "weeds" of grass-land. Various other species may occur locally, and sometimes a plant that is uncommon in most places may be present in abundance in isolated fields in certain districts, as, for example, fritillary (*Fritillaria meleagris*) in meadows near Oxford and Framsden (Suffolk) and daffodil (*Narcissus pseudo-narcissus*) in various parts of the country. Bracken (*Pteris aquilina*) is often troublesome on common grazing land, but is less usual as a weed on grass-land that is under ordinary farm management.

Mosses and Fungi.—Two lower forms of plant life, mosses and fungi, often give trouble in grass-land and must be classed under the heading of weeds. Mosses are associated with damp soil conditions and usually indicate poor drainage. As they tend to spread thickly over the surface of the soil they enter into competition with the herbage and prevent satisfactory growth taking place, so that the presence of too much moss indicates that the herbage is of less value than it might be.

Fungi are very commonly found on grass-land in damp weather, but they give most trouble when they form "fairy rings," as they cause the grass to become very uneven in growth. The rings are formed by the action of various fungi

which grow in a particular way and give rise to the characteristic appearance. The fungus consists essentially of long white threads or hyphae, forming a mycelium which ramifies and spreads through the soil. At intervals this mycelium throws up fructifications popularly known as toadstools or puffballs. Frequently these toadstools are fairly slight and of a medium size, 2-4 inches across, but occasionally they are very large and solid, measuring from 8-10 inches in diameter.

The particular fungi which form the ring begin to grow from a central point and branch outwards in all directions, the fructifications being thrown up year after year on the outer edge of the ring, which grows bigger annually. The area occupied by the ring the previous year seems to be particularly well manured by the fungus, as the grass thereon grows luxuriantly and is always very dark in colour. The affected areas are marked out by their luxuriant growth and dark colour, even in mowing fields in which the grass is knee deep. In pastures the grass of the rings is much appreciated by stock which keep it very closely cropped, but still the dark colour is evident. After one year of heavy growth the transient stimulus is apparently exhausted and the herbage falls behind that of the rest of the field, indicating that the ground has been seriously impoverished. The personnel of the herbage also changes. There is no fixed scheme of colonisation, but in each field the growth within and without the ring shows distinctive differences. Sometimes yarrow (*Achillea millefolium*) and ribgrass (*Plantago lanceolata*) appear among the thick grass of the ring, though they are absent elsewhere; sometimes cocksfoot is the chief grass associated with a good deal of hogweed. Another rather usual combination is field brome and rough meadow-grass, frequently combined with sorrel and cocksfoot. One very perfect example seen at Wickwar (Glos) consisted chiefly of ryegrass and cocksfoot. Within the ring the herbage was shorter and showed a mixture of grasses and weeds that indicated poverty of soil. It included vernal-grass (*Anthoxanthum odoratum*), rough meadow-grass, dog's tail, very little cocksfoot and an abundance of weeds.

Too many fairy rings are not desirable in grass-land, but unless they are so abundant as to threaten the herbage seriously it hardly pays to attempt to eradicate them. Liberal manuring will do much towards getting rid of them, but definite efforts at eradication are better reserved for lawns and special pieces of grass-land.

Vegetation of Special Areas of Grass-land.[1]

In the course of a survey of grass-land one thing gradually forces itself upon the attention, i.e. the marked effect that slight differences in level of soil or conditions of life has upon the herbage. Areas round gates and paths through fields are sharply marked out in this way, and they are characterised by a very definite type of vegetation.

Round the gates the soil is usually much trodden, so that its surface becomes more or less free from the ordinary grasses of the field. It often happens that this trodden soil is colonised by certain weeds more usually found on arable land, such as knotgrass (*Polygonum aviculare*), swine-cress (*Senebiera coronopus*), annual meadow-grass (*Poa annua*), mayweed (*Matricaria inodora*), all plants that do not intrude into the general herbage. Frequently the vegetation is still more characteristic. The grasses that do occur—often rough meadow-grass (*Poa trivialis*) (Fig. 41 C)—frequently assume a prostrate habit. One plant is almost ubiquitous in such situations. Wherever a field is much trodden, there almost certainly to be found is the greater plantain (*Plantago major*) (Fig. 41 A), and the more trodden the soil the finer the plant seems to grow. Paths are often demarcated by this plantain, and it appears even in places where not a vestige of it occurs in the regular herbage. Silverweed (*Potentilla anserina*) (Fig. 41 B) comes a very good second to the plantain, but is more apt to congregate round gates and cart tracks than along footpaths. Locally the broad dock (*Rumex obtusifolius*) and creeping thistle (*Cirsium arvense*) occur in abundance, and occasionally the hoary plantain (*Plantago media*) may be observed. In one instance, at Falfield, Glos, where the path through a field was still green and not bare, it was colonised by a thick carpet of daisy (*Bellis perennis*) and dove's-foot crane's-bill (*Geranium molle*); but this was an exceptional case.

Wherever a *manure heap or stack* is placed in a field the grasses underneath are more or less completely killed out, and on the removal of the stack a bare area is left on which colonisation begins. The manure introduces various weed seeds, usually from arable fields, and such species as knotgrass, mouse-ear chickweed, fat hen, shepherd's purse, chickweed, orache, thyme-leaved speedwell, toadrush and groundsel, may usually be

[1] Brenchley, W. E. (1916-17), "West Country Grass-lands," *Jour. Bath and West and Southern Counties Soc.*, XI, pp. 104-108.

FIG. 41.—PLANTS COMMON IN TRODDEN PLACES.

A. Greater Plantain (*Plantago major*).
B. Silverweed (*Potentilla anserina*).
C. Rough-stalked Meadow-grass (*Poa trivialis*).

found. Here again the prostrate habit of the surviving grasses is noticeable. These may include Yorkshire fog, cocksfoot, and ryegrass, as well as rough meadow-grass, and of these the last-named is one of the first to resume the upright habit. The effect of a manure heap on the herbage that eventually clothes its site is very persistent. After eighteen years, in one case at Tortworth Park, the position was still marked by the super-luxuriant growth of the grass, which lodged badly even when the rest of the field is not at all laid.

On the sites of *old ricks* arable weeds are not so usually found, but strong growths of broad dock, dandelions, and nettles are often seen, and these are sometimes surrounded by a ring of cocksfoot associated with sorrel (*Rumex acetosa*). Field brome (*Bromus arvensis*) is also rather fond of such situations and was found dominant at Berkeley on the site of an old heap of grips (seconds lime) that had been spread on the ground.

In the *shadow of trees* the herbage takes on a distinctive character, particular species growing in definite association. Three marked species are cocksfoot, foxtail, and rough meadow-grass, but even these are divided amongst themselves. In the Gloucestershire fields cocksfoot was to be found in abundance under almost every tree, sometimes dominating the situation, sometimes with either foxtail or rough meadow-grass sharing the pre-eminence. The density of shadow influences the distribution considerably. Under big trees which cast very dense shade, cocksfoot and foxtail may often be found dominant towards the outer edge of the shade ring, whereas in the dense shadow near the bole they may be replaced by rough meadow-grass and sometimes by smooth meadow-grass (*Poa pratensis*). Less frequently under big trees rough meadow-grass and foxtail share dominance, with cocksfoot only occurring occasionally.

In some cases, where the hedges are high enough to cast a real shade, resembling the partial shade under the smaller trees, cocksfoot and foxtail grow most luxuriantly along the edges of the fields, forming bands many feet broad which cease abruptly towards the edge of the shade line. Comparatively few other species occur in any quantity in the shadow of trees, and usually only one or two of these are at all conspicuous in each instance. Tall and bulbous buttercups, wild chervil (*Anthriscus sylvestris*), sharp dock and broad dock, sorrel, pignut (*Conopodium denudatum*), and field brome practically sum up the colonists, though occasionally creeping

thistle, nettle, and ryegrass venture as far as the outer edge of the shade circle.

Occasionally the vegetation under trees takes on a totally different character. Under certain trees in Tortworth Park (Glos) *Bromus sterilis* absolutely dominated the situation, in some instances to the total exclusion of all other species, in others admitting foxtail on sufferance. Under a very large oak tree on a mowing field, also at Tortworth, the deep shade was colonised by an abundance of pignut, little else being evident except an undergrowth of grass. Farther out, in the less dense shadow, cat's ear (*Hypochæris radicata*) was dominant, very little pignut being present. At the edge of the shade, merging into the main part of the field, the cat's ear was joined by masses of dog daisies, which also occurred in abundance out in the open, giving the field the appearance of a sheet of white and gold.

When fields are grazed by cattle, they are frequently scattered with clumps of coarse, luxuriant grass that the animals leave severely alone. These clumps spring up around the droppings, and are very generally composed largely or entirely of cocksfoot, with or without sorrel in varying amount. The cocksfoot is obviously much encouraged by manuring, and under favourable circumstances will grow so strongly as to overpower nearly everything else. On this account care has to be used in the application of dung to certain fields where this grass flourishes. To some people the prevalence of cocksfoot in clumps round the droppings and also under trees suggests that in the latter case the grass is encouraged by the fact that the animals seek the shade of trees during sunny weather, so that the ground there gets heavily manured, thus giving the cocksfoot a grand opportunity. This may be true to a large extent, but even without heavy manuring cocksfoot tends to grow very luxuriantly in the shade; indeed, in some parts of the world it is called orchard grass because it forms the chief constituent of the herbage under the fruit trees. The tussocks disfigure the fields and help to make the grass patchy. To keep them down it is well to follow after cattle with horses or sheep, as these have not the same objection to eating the grasses in the clumps.

CHAPTER XII.

USES OF WEEDS.

THE descriptions of plants given by very early writers and the old herbalists, as Dioscorides,[1] Pliny,[2] Gerarde[3] and Parkinson,[4] lay special stress upon their medicinal values, many of which, to our modern idea, are extremely fanciful and far-fetched. The majority of wild plants then known were used for medical purposes or for herb teas, but few of these have retained their reputation to the present day. The stitchwort gained its name because it was reckoned "good against stitches and pains in the side".[1] The creeping buttercup was used to raise blisters on the wrists of those attacked by ague, and the seeds of corn cockle were dried, powdered and used as a cure for jaundice.[5] Kidney vetch (*Anthyllis vulneraria*) once had the reputation of being a good cure for wounds, and hence received its specific name *vulneraria*,[6] while the scarlet pimpernel, pounded to dust and drunk in water, was regarded as a remedy for the bite of a mad dog.[1] Many other such ideas were rife, but all have passed away. The mayweed was formerly much used for medical purposes, but, curiously enough, after being practically neglected for a long time it came back into use in connection with homœopathy.[6] The juice of the sun spurge (*Euphorbia helioscopia*) is still sometimes used for removing warts,[7] and when rubbed on the skin behind the ear is said to be a cure for toothache.[8]

The few weeds which are still commonly utilised in medicine, as colchicum, hemlock, and poppy are treated in detail

[1] "Leechdoms, Wortcunning, and Starcraft of Early England" (1864). Collected and edited by Oswald Cockayne. (Includes Dioscorides, A.D. 100.)
[2] Pliny's "Natural Historie," Holland's Translation (1634).
[3] Gerarde, "The Herbal" (edited by T. Johnson), (1633).
[4] Parkinson, J. (1629), "Paradisi in Sole".
[5] Hogg, R., and Johnson, G. W. (1863), "Wild Flowers of Great Britain".
[6] Wilson (1847), "Rural Cyclopedia".
[7] Knapp, F. H. (1846), "Botanical Chart of British Flowering Plants".
[8] Pratt, A., "Flowering Plants, Grasses, and Ferns of Great Britain,"

later on in the chapter. Before the increase in the importation of cheap vegetable dyes from foreign countries, and before the great advances made in connection with chemical dyes, wild plants played an important part in the provision of these essential articles of commerce. Among the weeds, ladies' bedstraw (*Galium verum*), sorrel (*Rumex acetosa*), agrimony (*Agrimonia eupatoria*), nettle (*Urtica dioica*), woodwax (*Genista tinctoria*), willowweed (*Polygonum persecaria*) were all used for dyes, and wild mignonette or dyer's rocket (*Reseda luteola*), besides providing a beautiful yellow dye, was used for making the paint called "Dutch pink".[1] In the time of Pliny wild orache was even used to colour the hair black.[2]

Some of the uses to which the weeds are put are very singular and interesting. The stalks of white deadnettle are made into whistles by country boys, and in the time of James I ladies used carrot leaves instead of feathers. The seed of wild oat is provided with twisted awns which uncoil when in contact with water, so it has been used as a hygrometer, and also, as the hairs and bent awn cause the seed to resemble closely a fly, it is used by rustic fishermen for catching trout.[1]

Many of the commonest farm weeds have a varied history of usefulness in old and modern times, and therefore they are treated individually in the following paragraphs.

Achillea millefolium (Yarrow).—This plant is highly astringent and was anciently much prized as a vulnerary. According to the old leechdoms it was widely used for curing wounds, and the story runs that it received its name because Achilles found it and used it to cure those who had been wounded with iron.[3] As late as 1863 it was used among the Scottish Highlanders to make an ointment for drying and healing wounds, and it is possible that this is still done.[4] It is a useful astringent in cases of hæmorrhage, and yet, curiously enough, it is called "nosebleed" because the leaves are supposed to cause bleeding if put into the nose.[3] In some parts of Sweden and Africa, yarrow has been employed in the making of beer in order to render it more intoxicating.[5] Some agriculturists regard it simply as an agreeable condiment for cattle, while others consider it to be a most valuable ingredient in good nutritious herbage.

[1] Lindley, J., and Moore, T. (1889), "Treasury of Botany".
[2] Pliny, *loc. cit.* [3] Leechdoms, *loc. cit.* (Includes Ampuleius.)
[4] Hogg, R., and Johnson, G. W., *loc. cit.*
[5] Woodville, W. (1790-1792), "Medical Botany".

Agrimonia eupatoria (Agrimony). This has always had a considerable reputation for medicinal purposes, and an infusion of agrimony was employed by the peasantry of the south of England for feverish colds.[1] The Canadians are also said to have successfully used an infusion of the root in certain fevers. During the war the fruits were used as a constituent of the tea mixtures sold in Germany. The plant contains tannin and has been used in Germany for dressing leather. It also yields a good colouring matter which dyes wool bright nankeen if the plant is gathered when the flowers are beginning to open, but if gathered in September the dye is darker.[2]

Agropyron repens (Couch-grass).—Although this is such a pestilent weed, it has great capabilities of usefulness if rightly employed. From very early times its medical value was recognised. Pliny claimed that it was useful for healing wounds, and that poultices made from it prevented inflammation of injuries. Gerarde also emphasised the healing powers of the plant, and Culpepper[3] went so far as to say that "a physician holds half an acre of them to be worth 5 acres of carrots twice told over". Horses and cattle are particularly fond of the rhizomes or underground stems. At Chedzoy, in Somerset, in 1916, the couch grass that was cultivated out was thrown into a stack, with the intention of using it for rick bottoms. Cattle were turned into the field, and they made a raid on the stack and rapidly demolished it, though the stuff was never fed to them.[4] In Rome and Naples the rhizomes are washed and mixed with carrots as food for horses.[1] They contain a considerable amount of nutritive matter, similar in quality and quantity to that in the potato, and this can easily be extracted in the form of a starchy powder resembling arrowroot, which is quite good for human food. During the war a coffee substitute was prepared from the rhizomes, and the latter were also dried and ground into flour.

Apart from its feeding value, couch-grass is valuable as a manure if made into a compost with lime, or burned, and the ashes spread over the ground. The rhizomes can also be worked up into paper, and although the quality is at present not very good it is useful for rough work, and improvement may be effected as experience is gained.

[1] Wilson, *loc. cit.* [2] Hogg and Johnson, *loc. cit.*
[3] Culpepper, "British Herbal".
[4] Brenchley, W. E. (1917), "West Country Grasslands," *Jour. Bath and West and Southern Counties Society*, XI, pp. 102-103.

Agrostis spp. (Bent grass).—This weed is little used except as feed for animals, but in Italy and the South of France the stolons have sometimes been gathered into bundles by the poor and sold in the market as horse provender.[1] *Agrostis alba* has been cultivated for fodder, but this is seldom done now.[2]

Allium ursinum (Ramsons).—Gerarde says that in the Low Countries the leaves were stamped and eaten as a sauce, and that the leaves were sometimes eaten in April and May with butter.[3] In Khamchatka large quantities are stored for winter use, both for culinary purposes and as an antiscorbutic.[4]

Borago officinalis (Borage).—The young and tender leaves are good in salads or as a pot-herb, and formerly were often put into negus or cold tankards. Occasionally the leaves and flowers have been employed as an ingredient in brewing.[1]

Camelina sativa (Gold of pleasure).—Although regarded as a weed in England, this is such a useful plant that it is cultivated on the Continent in Holland, Belgium, Germany, North France, etc., and in South Europe produces two crops a year. It yields an excellent oil which has practically no smell and gives a brighter flame and less smoke than oil of rape or mustard.[1] The oil was noted even in Gerarde's time, for he says it was used by the poor peasants in their banquets, and by rich people in their lamps.[3] It is now chiefly used by soapmakers. The cake obtained after expressing the oil has been suggested for use as cattle-food, but seems to be too acrid to be satisfactory for that purpose.[2] The stems are very fibrous, being tough, hard, and durable, so that they are employed for such purposes as thatching temporary buildings and for making brooms, sack-cloth, sailcloth and packing paper. The plant has been used as green fodder for sheep, and poultry and geese are very fond of the seeds and quickly fatten on them.[5]

Carex (Sedge).—The stiff strong leaves are occasionally used by the poorer farmers for fodder, litter, thatch, and fuel, and in Kent the leaves of the larger kinds have been employed to fasten the hop-vines to the poles. The Laplanders protect their hands and feet in winter with a flaxy fibre made from sedge, and by the Italians it is used to stuff crevices of casks, and to make bottoms of chairs and covers for flasks of Florence oil.[1]

Chenopodium album (Fat hen).—The seeds have occasionally

[1] Wilson, *loc. cit.* [2] Lindley and Moore, *loc. cit.*
[3] Gerarde, *loc. cit.* [4] Hogg and Johnson, *loc. cit.*
[5] Johnson, C. P. (1861-62), "Useful Plants of Great Britain".

been ground into flour for bread-making, as, for instance, during the Russian famine of 1891-1892.[1] They are also used in the preparation of shagreen, being pressed into the moist hides to form the granulations so characteristic of that leather.[2] The plants possess a certain manurial value if they are ploughed in when green, as the potash content is about 10·9 per cent., the same as in *Stellaria media*.[3]

Cichorium intybus (Chicory).—In France, Italy, Switzerland and other parts of Europe this has been specially cultivated for stock feed, and was much esteemed for cows, being usually made into hay.[4] In the eighteenth century the roots were gathered for eating before the flowering stems shot up, sometimes being dried and made into bread.[5] The more modern use is as a substitute or adulterant for coffee. The roots are kiln-dried or roasted and ground into powder, and added to coffee either openly or fraudulently (as some people prefer ground chicory to genuine coffee, and others have a strong objection to it).[6] During the war the value of chicory as a coffee substitute was so well recognised that in Germany and Austria the whole crop was reserved for this purpose, its use in feeding animals being prohibited. The dried roots contain a good deal of sugar, and have been used instead of oats for feeding purposes.[7]

In Belgium it has long been used in a pure state instead of coffee, and in the same country the roots are boiled and eaten like parsnips. The plant is much cultivated in some parts of England, the herbage being used as food for cattle and the roots as an article of commerce. The leaves are often blanched and eaten for salad,[8] and the roots possess medicinal properties closely resembling those of dandelion. Altogether the plant is distinctly useful in many ways, and it is even stated that this and some very similar plants constitute half the food of the Egyptians.[9] At the present time it is a most valuable constituent of "Elliott's mixture," which has proved so efficacious in eradicating wild onion from arable land.[10]

[1] Hanasek, T. F. (1915), *Zeitsch. für Untersuchung der Nahrungs- und Genussmittel*, 29, pp. 17-25.

[2] Knapp, *loc. cit.*

[3] Kling, M. (1915?) "Über die chemische Zusammensetzung einiger Unkräuter sowie deren Wert als Futter-und Düngemittel," *Landw. Versuchs-Stat*, LXXXV, pp. 433-470, Summ. in *Jour. Bd. Agric.*, XXII, pp. 362-363.

[4] Andrews, G. H. (1853), "Modern Husbandry," p. 287.

[5] Woodville, W., *loc. cit.*

[6] Wilson, *loc. cit.*

[7] See *Jour. Bd. Agric.*, Vol. XXIII, pp. 499-500.

[8] Hogg and Johnson, *loc. cit.*

[9] Pratt, *loc. cit.*

[10] Voelcker, J. A. (1911), "Eradication of Wild Onion," *Jour. Roy. Ag. Soc.*, 72, pp. 404-409.

Colchicum autumnale (Meadow saffron).—Like many other poisonous plants the meadow saffron has valuable medicinal properties, and the seeds have often been prescribed for gout and rheumatism.[1] The Turks infuse the flowers in wine to render it more intoxicating, and the bulbs are said to be eaten with impunity in the autumn by the peasantry in Carniola.[2] The poisonous nature of all parts of the plant causes it to be looked on askance in this country, many instances of poisoning of animals and human beings having been traced to this source.

Conium maculatum (Hemlock).—As far back as the time of Theophrastus a most powerful poisonous juice, used in medicine and also for causing death,[3] was obtained from the root of this plant, and there is a tradition that the poison drunk by Socrates was hemlock. The fruits are the most convenient sources of the alkaloid coniine as used for medical purposes. It is said that the green unripe fruits possess the major part of the peculiar properties of the plant, and that they may be dried without loss of activity.[1] Hemlock has a peculiar sedative effect upon the motor nerves and occasionally used to be prescribed for that purpose, but Cushny states that this drug, long widely used in therapeutics, has on more accurate investigation failed to maintain its position and passed into disuse.[4] The plant is supposed to give off a narcotic effluvium which is most active in hot and dry seasons and in warm countries. Linnæus says that sheep eat the leaves, but that horses, cows, and goats refuse them, while Ray states that the thrush will feed upon the fruits even when corn is to be had.

The plant is often called kecks or caxes, apparently because spinsters used the stems for caxes to wind yarn upon.[2]

Conopodium denudatum (Pignut).—The edible quality of the tuberous roots has long been recognised, for, according to Gerarde, in the seventeenth century the Dutch people ate them boiled and buttered, as we do parsnips and carrots.[5] They have a flavour scarcely inferior to that of chestnuts, and it is possible that in Holland and the Alps they are still so used. Apparently they are palatable and very nutritious, either raw,

[1] Flückiger and Hanbury (1874), "Pharmacographia: A History of Drugs".

[2] Hogg and Johnson, *loc. cit.*

[3] Theophrastus, 322 B.C., "Enquiry into Plants," (Hort's Translation).

[4] Cushny, A. R. (1918), "Pharmacology and Therapeutics, or the Action of Drugs," p. 306.

[5] Gerarde, *loc. cit.*

roasted, or boiled, and Wilson thought it a great pity that earthnuts were not cultivated as an article of dessert.[1] In some parts of England they are sliced and put into soups, and in Sweden they are extensively used and form a regular market article. Pigs, with their keen sense of smell, are able to detect the pignuts[2] underground as they do truffles. During the war the use of this plant was advocated as a vegetable.[3]

Convolvulus arvensis (Bindweed).—Is greatly enjoyed by rabbits in captivity. Analytical and feeding experiments in Germany (1914) have shown that the green stems and leaves have a high nutritive value as green fodder, and that they are also useful in manure.[4]

Equisetum arvense (Horsetail).—Is disliked in pastures, for although it is eaten by horses it is injurious to sheep, and causes violent scouring in cattle when forced to eat it by hunger.[1] It has a considerable economic value as it abounds in particles of mineral matter, rendering this and other species particularly suitable for polishing hardwoods, ivory, brass, etc. An allied species, *E. hyemale*, used to be imported from Holland under the name of "Dutch rushes" and was used by Northumberland dairymaids for cleaning milk pails.[5]

Fumaria officinalis (Fumitory).—Is readily eaten by cows and sheep, but horses will not touch it and goats dislike it when it is full grown.[1] The whole plant has a considerable medicinal reputation as a blood purifier and cosmetic, the leaves being the most effective part. The Japanese recognise the medicinal value of the plant. In Picardy the plant is used to curdle milk.[2]

Galium aparine (Goosegrass).—In the time of Dioscorides goosegrass was made into filters for straining milk, and, Linnæus mentioned that in his day the stalks were applied to the same purpose. Even in our country places it is occasionally used in this way when a sieve is not at hand.[6] In Sweden the horny fruits are dried and slightly roasted as a substitute for coffee,[7] and they have also been thoroughly ground for cattle food.[8] Occasionally, too, the dried plant is infused in

[1] Wilson, *loc. cit.* [2] Hogg and Johnson, *loc. cit.*
[3] Crichton Browne, J. (1917), "A Neglected Source of Food Supply," *Selborne Magazine*, Vol. XXVIII, pp. 85-87.
[4] Kling, *loc. cit.* [5] Knapp, *loc. cit.*
[6] Pratt, *loc. cit.* [7] Johnson, C. P., *loc. cit.*
[8] Bernatsky, J. (1915). See "Internat. Review Science and Practice of Agriculture" (1916), VII, pp. 245-246.

hot water and drunk as tea. A red dye can be obtained from the root.

Galium verum (Ladies' bedstraw).—The plant is of distinct value in dyeing, as a bright yellow colour is obtained from the flowering tops boiled in alum, and the roots yield a red dye equal to madder.[1] The plant is made use of by the Highlanders, who boil the roots with the yarn, adding alum to fix the colour.[2] Some authorities say the dye is superior to madder, and at one time it was recommended for cultivation, when experimental plots yielded a crop of 12½ cwt. dried roots per acre. It has been supposed that the bones of animals turned red if the beasts fed on this plant, the colouring taking place sooner in young than in fully grown animals, while it was deepest in those whose bones were hardest and thickest.[3] The popular name of "cheese rennet" is derived from the fact that the whole plant when bruised will curdle milk, and in the Hebrides it is used for this purpose, combined with leaves of common nettle (*Urtica dioica*) and a little salt. It is also used both to colour and flavour milk intended for cheese, and vinegar is sometimes made from its juices.

Genista tinctoria (Wood-wax).—This yields a bright yellow dye, and if articles dyed with it are then dipped into a blue solution of woad (*Isatis tinctoria*) the celebrated "Kendal green" is obtained.[4] The colour is fixed with alum, cream of tartar, and sulphate of lime.[5]

Geum urbanum (Avens).—The herbage is greedily devoured by sheep, and when young may be used for salads and other culinary purposes.[1] The plant was much esteemed by herbalists, and since 1780 has been used as a febrifuge,[6] and has even been recommended as a substitute for Peruvian bark in the cure of intermittent fevers. If gathered in spring and put into ale avens gives the liquor a pleasant flavour and prevents it turning sour. The root, if chewed, is said to overcome disagreeable odour of the breath. Medically it was once much in repute as a specific for diarrhœa and dysentery.[7]

Heracleum sphondylium (Hogweed).—Has been extensively used in Sussex for fattening hogs, and makes good nourishing food for cattle.[1] In the Hebrides the stems are eaten, and an attempt has been made to manufacture sugar from the

[1] Wilson, *loc. cit.*
[2] Knapp, *loc. cit.*
[3] Pratt, *loc. cit.*
[4] Lindley and Moore, *loc. cit.*
[5] Johnson, *loc. cit.*
[6] Woodville, *loc. cit.*
[7] Stephenson, J., and Churchill, J. M. (1834), "Medical Botany".

stalks, but as it requires 40 lbs. of dried stalks to produce one lb. of sugar, the amount of labour required renders the process too expensive.[1] The inhabitants of Kamtchatka make a great delicacy from this plant by peeling the stalks, drying them in the sun, and then laying them in the shade in bags till a saccharine efflorescence is formed. This is shaken off and eaten and has a taste like liquorice. The Russians prepare the stalks in the same manner and then distil an ardent spirit by fermenting them in water with bilberries (*Vaccinium uliginosum*). This spirit is said to be superior to that distilled from corn.[4]

Linaria vulgaris (Toadflax).—In Sussex the plant used to be called gallwort and was put into the water drunk by poultry in order to cure them when drooping. The flowers afford a yellow dye, and in Sweden the plant is boiled in milk and used to attract and destroy flies.[1] It has some medical value as a purgative.[4]

Lithospermum arvense (Corn gromwell).—The outer part of the root is red and stains paper, linen, oily substances, and the human skin.[3] A rustic substitute for rouge is obtained from the roots,[1] which is used to give a brighter tint to their cheeks on festive days by the girls in the north of Sweden. It also provides a colouring matter for ointments, hence obtaining the name "bastard-alkanet".

Nepeta glechoma (Ground-ivy).—According to Wilson ground-ivy or ale hoof was a chief ingredient in the manufacture of ale by the ancient Saxons, and in his time was still occasionally used by the poor for infusion in ale or beer, as a remedy against internal disorders.[3] Other authorities state that it was formerly used in the fermentation of beer and other liquors, to cause the foam on the fermented drink. If the leaves are thrown into the vat with ale they clarify it and give it a special flavour. Ale-hoof was generally used for this purpose till the reign of Henry VIII, when hops were substituted and soon ousted the older plant from favour.[4] As late as 1889, and possibly to the present day, ground-ivy was held in repute by village herbalists, who dried it and used it as a substitute for tea.[2] For obstinate coughs it is a favourite remedy with the poor, but is not much valued by the medical profession.[5]

Orchis mascula (Early orchis).—The roots of this orchis and some allied species are extensively used for the manu-

[1] Pratt, *loc. cit.* [2] Lindley and Moore, *loc. cit.* [3] Wilson, *loc. cit.*
[4] Hogg and Johnson, *loc. cit.* [5] Woodville, *loc. cit.*

facture of the food-stuff called "salep" or "saleep". *Orchis mascula* is very plentiful in the moist meadows of Gloucestershire and other parts of England, and is much cultivated in the East, where it yields a considerable portion of the diet of the inhabitants of Turkey, Persia and Syria. The root is heated and dried in the air, and forms a somewhat horny substance called salep, which is supposed to contain a very large quantity of nutritious matter within a very small bulk. It has the property of concealing the taste of salt water and of retarding the natural souring of milk, and in certain proportions it is said to be a very useful and profitable addition to bread.[1] Opinions differ as to its medicinal value, some authorities claiming that it is of considerable service in several diseases, others denying that it is of much use in this respect.

Ornithogalum pyrenaicum (Spiked Star-of-Bethlehem).—This weed is very local in occurrence, but round about Bath it is so abundant that the young shoots or flowering spikes are collected in the spring and sold in the market as a substitute for asparagus, hence the variety of popular names connected with "asparagus"—Bath asparagus, French asparagus, Prussian asparagus.[2] It would probably be improved by cultivation. The seeds are said to impart a flavour to bread.[3]

Papaver rhœas (Red poppy).—The valuable properties of this plant have long been recognised, as even in the time of Theophrastus (circa 322 B.C.) it was used in medicine. Pliny acknowledged the narcotic nature of the poppy, and stated that it reduced inflammation of the eyes when used as a liniment. At the present time this particular species is chiefly valued for its petals which yield a fine red colouring matter, especially if used in the fresh state. The petals are collected for making a coloured syrup which has very slight narcotic properties.[2] Opinions differ as to whether the seeds are also narcotic, but they contain a farinaceous substance, combined with a bland oil which is expressed for use. This poppy oil is particularly sweet and wholesome and is often mixed with or used instead of olive oil for domestic purposes and for painting. The cake or residue after the oil is expressed forms a nutritious food for cattle. In some parts of Europe and the East poppy seeds are baked in cake or strewn upon bread and butter, and the Genoese encrust them with sugar and eat them as comfits. They are also eaten by Egyptians and

[1] Wilson, *loc. cit.* [2] Lindley and Moore, *loc. cit.*
[3] Hogg and Johnson, *loc. cit.*

Persians and were used by ancient peoples to excite an appetite, and in Poland and Russia they form an ingredient in soups and gruel. Poppy seed is given to singing birds as a cooling food when they are moulting, and is then called "maw seed".[1]

Plantago lanceolata (Ribwort plantain).—This weed is said to serve a useful purpose by preventing the soil from being washed away on thin soil overlying rocky substrata, as in the Welsh mountains, and it has been known thus to keep a large area fertile which would otherwise have been barren.[1] It has also been sown on sandy land as food for sheep.[2]

Plantago major (Greater plantain).—According to Pliny this plantain is very astringent and was used instead of a cautery or searing iron, but it is rather doubtful if he really meant our modern species. In the old Leechdoms or medical works many medicinal properties were attributed to plantain, some of which seem more fanciful than real. The leaves of this species and of *Plantago media* (hoary plantain) are often applied to wounds by poor people. The seeds are very mucilaginous and useful in pulmonary diseases, and are also much in demand among bird fanciers as food for canaries.[2] The mucilage of some species of plantain is used by manufacturers for stiffening muslins.

Polygonum aviculare (Knotgrass).—The fruit is emetic and purgative,[3] and the whole plant is greedily eaten by pigs, so that in some countries it is called hog-weed. Gerarde states that it used to be given to pigs when they were sick and would not eat their food. In Alsace knotgrass has been largely used for making into hay,[1] and it is said to be very useful in rearing silkworms.[4] Thunberg says that in Japan a blue dye resembling indigo is prepared from this plant.

Polygonum convolvulus (Black bindweed).—Some writers claim that the seeds are quite as good as those of buckwheat and that they are produced in greater abundance. The juice expressed from the bruised leaves is very purgative.[1]

Potentilla anserina (Silverweed).—The silvery foilage is greatly relished by geese. The roots are eagerly eaten by pigs and much appreciated by children, who roast them over the fire. In the Hebrides the roots are an article of diet, either raw or boiled. They contain a good deal of nutriment and in times of scarcity the people of the islands of Tiree and Coll

[1] Hogg and Johnson, *loc. cit.*
[2] Knapp, *loc. cit.*
[3] Lindley and Moore, *loc. cit.*
[4] Pratt, *loc. cit.*

have used them for bread and lived for months together almost entirely on this food.[1]

Potentilla reptans (Cinquefoil).—The roots contain tannin and have been employed in the preparation of leather.[2] A quaint old use of the plant is that given by Pliny—that "it is used for purging or blessing of the house against naughtie spirits or enchantments".

Potentilla tormentilla (Tormentil).—The roots provide a most agreeable astringent, aromatic and efficacious. In the western isles of Scotland and in the Orkneys they are used for tanning leather and are considered to be superior to oak bark; they are boiled in water and the leather is then steeped in the cold liquid. The roots also contain a red colouring principle, soluble in alcohol but insoluble in water.[3]

Poterium sanguisorba (Salad burnet).—The herbage has much the flavour of cucumber and was used in the old English drink known as "cool tankard".[3] The French and Italians[4] esteem it as a salad.

Pteris aquilina (Bracken).—Wilson gives an excellent summary of the various uses of this plant. In earlier days it was in great request for thatch, it was formerly employed in the manufacture of both glass and soap, and possesses sufficient astringency for the purpose of the tanner. In seasons of scarcity it makes useful fodder, and it forms good litter in the cow house and piggery. Bracken often serves as tolerably good manure for potato crops, and is used for the winter protection of esculent roots. It is a common fuel for heating ovens and burning lime—and yet, is one of the greatest pests of pastoral farms and renders an enormous aggregate of our country unavailable for agricultural purposes.[4] In Scotland it is employed as a vermifuge.[5] It is reported that the young fronds make a good fodder for pigs if they are mixed with potatoes, steamed and pounded, and also that the rhizomes are rich in food material, especially before the end of April, and may be fed to pigs.[6] Experiments made during the war show that a good

[1] Pratt, *loc. cit.*
[2] Hogg and Johnson, *loc. cit.*
[3] Lindley and Moore, *loc. cit.*
[4] Wilson, *loc. cit.*
[5] Knapp, *loc. cit.*
[6] (*a*) Zeit-Nahrungs Genussmittel (1916), 32, p. 447.
(*b*) "The Uses of Bracken Fronds and Roots," *Jour. Bd. Agric.* (1917), XXIII, 1252-1255.
(*c*) Hansen und Mez (1916), "On the Use of Fern-root (*Pteris aquilina*) in German Pig-feeding Experiments," *Deutsche landwirtsch. Presse.*, 43, No. 22, p. 193.
(*d*) *Weiner Landw. Ztg.* (April 22, 1916), Summ. in *Jour. Bd. Agric.*, XXIII, p. 499.

deal of potash can be obtained by burning bracken and utilising the ash.[1]

Ranunculus acris (Tall buttercup).—Possesses a very acrid juice and is sometimes used fresh as a plaster for causing local irritation, as in cases of rheumatism and hip disease. Care is needed in application, or it may cause ulcers, but the plant loses its virulence on dying. Withering says that beggars use it to ulcerate their feet, which they expose in that state to excite compassion.[2] The curious superstitions that attach themselves to some plants are well exemplified in this case, for Ampuleius wrote, "For a lunatic, take this wort and wreathe it with a red thread round a man's neck when the moon is on the wane, in the month which is called April, in the early part of October, soon he will be healed".[3]

Rhinanthus crista-galli (Yellow rattle).—The plants are supposed to be useful for exterminating vermin, if the seeds and seed vessels are boiled in water and poured over the haunts of bugs and fleas or over animals infested with lice.[4]

Rumex acetosa (Sorrel).—The leaves of this plant are acid and astringent, and were much cultivated in gardens for eating cooked or as salads, especially in the time of Henry VIII. It has, however, been almost entirely supplanted for this purpose by the French sorrel, which has large succulent leaves, and the native species has almost disappeared from cultivation.[5] A rustic custom, which probably still survives, is to serve it as sauce with roasted meat, hence the name "green sauce". The herb is also beaten to a mash and mixed with vinegar and sugar. In some parts of Ireland the plant is eaten with milk and fish, and is capable of souring milk, being so used by the Laplanders.[4] A fine red dye is obtained by boiling the dried root. In some parts of Sweden when it is difficult to cultivate barley or rye, a bread made from bark and another made from common sorrel often stand between the poor people and starvation.[6]

A substitute for salt of lemon used to be extracted from the roots in Germany and exported to England. In its preparation the mucilaginous parts were separated by use of water and pipeclay and the salt was purified by several crystallisations.[4] It was also much employed in making verjuice.

[1] Berry, R. A., Robinson, G. W., and Russell, E. J. (1918), "Bracken as a Source of Potash," *Jour. Bd. Agric.*, XXV, pp. 1-11.
[2] Woodville, *loc. cit.*
[3] Leechdoms, etc., *loc. cit.*
[4] Hogg and Johnson, *loc. cit.*
[5] Lindley and Moore, *loc. cit.*
[6] Pratt, *loc. cit.*

The weed is of little agricultural importance, as it is never eaten by live stock unless they are unusually hungry, but its medicinal value as a cure or preventive of scurvy was recognised by some of the oldest writers.

Rumex obtusifolius (Broad-leaved dock).—Cattle will not eat the plant, but in the North of England the boiled foliage is used as food for pigs. Withering states that fallow deer eat it so greedily that it is rare to see a dock growing in a deer park. The name "butter-dock" is given because the large leaves are often employed for wrapping round butter and cheese. The root is very astringent, and acts in the same way as the powder or tincture of Turkey rhubarb. It was formerly used by dyers, and when powdered makes an excellent dentifrice.[1]

Rushes are among the plants that have gradually decreased in importance with the progress of civilisation. Nowadays rushes are considered chiefly as troublesome weeds, which are to be eradicated whenever possible. In older times many useful articles of household economy were made from them as they were worked up into mats and into baskets of all descriptions, from coarse fishing baskets to finely woven ware.[2] The familiar term "rushlights" points to the use of the pith of some rushes for making candles. Little baskets and children's toys were made from the same pith. When twisted together rushes were used to make ties for bundles and other rustic implements, and it is probable that they provided the material for the earliest cordage. Indeed, the rushes of some countries are commonly made into ropes and cables, and in this country mats and chair bottoms were formerly manufactured from them.[1]

Scleranthus annuus (Annual knawel).—Cattle refuse to eat this, but sheep and goats will feed on it.[3] In some parts of the continent, as Sweden and Germany, it is said that a decoction is made and the steam inhaled as a remedy for toothache.[4]

Senecio vulgaris (Groundsel).—This abundant weed seems to be of little use for any purpose except as a food for cage birds. Few animals care for it except goats and pigs.[3] The expressed juice has been used to cause the evacuation of bot worms from horses.[4] The bruised leaves are healing if applied to boils, and an infusion can be used in small doses as a purgative and in large quantities as an emetic. It was far more valued by the old herbalists than it is now.

[1] Pratt, *loc. cit.*
[2] Pliny, *loc. cit.*
[3] Wilson, *loc. cit.*
[4] Hogg and Johnson, *loc. cit.*

Silene inflata (Bladder campion).—The boiled leaves are supposed to taste like peas or asparagus. They are eaten by the natives of Zante,[1] and were also used by the inhabitants of Minorca in 1655 after the corn crop had been destroyed by locusts.[2]

Sonchus oleraceus (Common sowthistle).—The bitter milky roots have occasionally been used for making bread.[3] The leaves were formerly eaten in Italy as salad, but have long been replaced by more palatable plants.[4] Hares and rabbits are greedily fond of the leaves, goats like it, and other animals often feed upon the plant.

Spergula arvensis (Spurry).—Although spurry is regarded simply as a pestilent weed in this country, it is much valued abroad as cattle food. Beasts, sheep, and poultry are very fond of it, and it has excellent fattening properties. Old writers state that in the Low Countries two crops can be obtained in a year, the first from a May sowing, when the plants ripen seed in August, and the second from a sowing made after rye harvest, which provides feed until the New Year.[5] The crop is either used as pasture, cut green, or made into hay. It improves the mutton of sheep and the milk and butter of cows, and is said to cause hens to lay more freely.[3] The seeds can be ground into a kind of flour, which makes a fair bread, especially if mixed with wheat or rye flour. It is often used for this purpose in Norway and Finland, particularly when other crops are short.[6] The seeds, when bruised, form a good cattle food, and when expressed they also yield a good lamp oil.

Stellaria media (Chickweed).—Is of little use except as food for birds and pigs, which are very fond of it. It has been boiled for use as spinach, and is said to have some nutritive value when treated in this way.[3] German experiments indicate that the weed has considerable manurial value, as it contains about 10·9 per cent. of potash.[7]

Taraxacum vulgare (Dandelion).—In the time of Gerarde and Parkinson this was much valued for medicinal purposes, and it is still recognised in therapeutics, though it does not rank high in value. The ground root is sometimes mixed with chocolate to make a palatable kind of dandelion tea.[8]

[1] Knapp, *loc. cit.*
[2] Hogg and Johnson, *loc. cit.*
[3] Wilson, *loc. cit.*
[4] Lindley and Moore, *loc. cit.*
[5] Houghton (1728), "Husbandry and Trade Improved," II, p. 374.
[6] Pratt, *loc. cit.*
[7] Kling, *loc. cit.*
[8] Johnson, *loc. cit.*

Theophrastus considered that the plant was too bitter to be fit for human food, but nowadays the young leaves are blanched and much relished in spring salads. The French people eat the young roots as well as the blanched leaves with bread and butter,[1] and in parts of Germany the roots are roasted, ground, and drunk instead of coffee by the poorer people, who claim that the beverage so prepared can hardly be distinguished from genuine coffee.[2] As fodder it is much liked by rabbits, pigs, and goats, but sheep and cattle do not care for it and horses will not touch it.[3] The leaves are sometimes used for feeding silkworms when mulberry leaves are not available.[4]

Tussilago farfara (Coltsfoot).—For many centuries the plant has been used in chest and lung troubles. Even in Pliny we read: "If the root of Folefoot be burnt upon the coles made with Cypres wood the smoke . . . is singular for an old cough". The leaves have certain demulcent and pectoral properties, and are employed in the manufacture of British herb tobacco, of which they form the chief ingredient, and which was formerly much used in chest complaints.[3] The smoking of the plant was strongly recommended by the old writers. The cottony down from the leaves has sometimes been utilised for filling pillows and cushions,[5] and it also makes a most excellent tinder when wrapped in a rag, dipped in a solution of saltpetre, and dried in the sun.

Ulex europaeus (Gorse).—Although this can hardly be reckoned as an ordinary farm weed, it has so many uses that it may find a place here. In spite of its spiny habit it forms a most excellent forage, though the older branches need to be bruised with a mallet before being fed. Old writers say that cattle appreciate it greatly and fatten on it as well as they do on turnips, that the milk of cows is as plentiful as though they were fed on grass, and the butter produced of excellent quality.[6] More recent work indicates that the gorse should be well crushed and freshly prepared, in order to prevent fermentation.[7] Mountain sheep thrive better when fed on gorse than on grass.[8] Horses prefer it to hay or even to corn, but as it tends to fatten them very much it is less suited for working animals.

[1] Stephenson, J., and Churchill, J. M., *loc. cit.*
[2] Woodville, *loc. cit.*
[3] Hogg and Johnson, *loc. cit.*
[4] Lindley and Moore, *loc. cit.*
[5] Pratt, *loc. cit.*
[6] Wilson, *loc. cit.*
[7] Fau, E., *L'Industrie Laitière* (1910), No. 42, pp. 677-679.
[8] Andrews, *loc. cit.*

In the Scilly Islands the ponies feed chiefly on the gorse they find in the hills.

Gorse is also good for fuel, and in Cornwall is cultivated for the purpose, being chiefly made into faggots for heating ovens. It burns rapidly with much heat, and was formerly used in lime burning. The ashes are rich in alkali, and are made into lye or worked up into balls with clay to serve as a substitute for soap.[1] They are also very valuable as manure, particularly on peaty soil.

Gorse forms good cover for game and shelter for young forest trees,[2] and it can also be used for hedges if kept closely trimmed. It is, however, not very resistant to frost, although it will stand salt spray if planted near the sea.

Urtica dioica (Common nettle).—This much-despised weed has, in days gone by, proved an exceedingly useful friend to mankind. The stem contains a large proportion of fibre, which has been manufactured into every grade of material from ropes and cordage to fine white linen. It was much used in the manufacture of textile fabrics by the ancient Egyptians,[2] and even at the present day supplies the inhabitants of Siberia with fishing lines and cordage, while in many villages of Piedmont it is made into cloth. In 1911 an Austrian firm devised a method of removing the gum from the rough fibre, the resulting finished product being a pure bleached fibre which was glossy, supple, and flexible. The war, moreover, has given a considerable impetus to the exploitation of this source of fibre, and so many improvements and inventions have been carried out that it seems likely that, with judicious methods of cultivation, nettles will prove a profitable crop. In 1916 the Central Powers had developed the industry to such an extent that nettle fibres were reported to cost 60 per cent. less than imported cotton, and the War Ministries were using it for manufacturing wagon-covers, tents, sackings, clothing materials, and even cloth for military underwear. In Denmark the nettle yarn has been worked up with wool, with satisfactory results. At first the warp was of wool, the woof of yarn spun from nettle fibres, and the resulting fabric, though not so soft as pure woollen cloth, possessed considerable strength and was suitable for men's clothes. Later on attempts were made to blend the wool and nettle fibres in the yarn, as better results were expected from such a combination.[3]

[1] Johnson, *loc. cit.* [2] Hogg and Johnson, *loc. cit.*

[3] See Brenchley, W. E. (1919), "The Uses of Weeds and Wild Plants," *Science Progress*, XIV, No. 53, pp. 128-129.

Steps were taken to organise the collection and cultivation of nettles, with the result that by 1918 it was estimated that 23,000 hectares (= 9292 acres) would be under nettle cultivation in Germany, with an estimated yield of 175,000 metric cwt. of fibre. The cultivation of nettles has also been encouraged in Hungary, a special company being formed to further the work. The plants will grow well on ground that is of little agricultural value, and in some plantations they have developed into shrubs as high as a man. In other cases plantations have been formed on moorland which is unsuitable for growing food crops, and it is claimed that by doing this the land is subjected to a process of slow, natural cultivation that in time will increase the agricultural value of the land.

Nettles when cut and dried can be used as fodder for domesticated animals. The latter will not touch the growing plants because of the stinging hairs, but shortly after cutting these hairs collapse from loss of water and are then innocuous. Nettles have long been cultivated in Sweden, as they can be grown on waste or poor land and are very resistant to extreme temperatures.[1] One great advantage is their rapid growth; with judicious cutting three crops a year can be obtained. Even where regular cutting is not practised the leaves and seeds are often collected and dried as winter food for fowls. The leaves are boiled in water to the consistency of gruel, and are then mixed with cooked potato peelings, while the seeds are added to other food and are found to stimulate egg production. Analyses made by Professor Hendrick[2] show that nettles may be very useful as feeding stuff. Young nettles from 12 to 18 inches high sampled in May contain much fat and ash, and as much albuminoid material as linseed cake. Older nettles cut in July are more fibrous and contain more soluble carbohydrates, but the percentage of nitrogen is higher than that in grasses. These figures indicate that dried nettles cut at the flowering stage are similar in analysis to hay made from leguminous crops. A yellow dye is obtained if the roots are boiled with alum, and the seeds when mixed with corn improve the appearance of horses, and it is said that horse dealers use them to give a

[1] Garcia Santos (1916), *A Vinha Portugueza*, XXXI, No. 9, pp. 276-280.

[2] *National Food Jour.* (11th Sept., 1918). See also *Jour. Bd. Agric.*, Vol. XXV, p. 992, 1918.

lively air to an animal before selling him. The chopped leaves are supposed to increase egg production when fed to poultry.[1]

Nettles also have their value as human food, the young tops being boiled in spring like spinach. They are used very largely in this way by the peasantry in the West of Ireland. A useful rennet is made by adding a quart of salt to three pints of a strong decoction of nettles. When a tablespoonful is put into a large bowl of milk the latter readily clots, forming a pleasant beverage, free from any flavour of nettle.[2] If a leaky wooden vessel be rubbed with a handful of nettle leaves the juice enters the cracks and coagulates, and the leakage is repaired, though no hint is given as to the length of time the repair holds good. The leaves are also placed on the top of baskets of Kentish plums to preserve the bloom—but it is doubtful whether the nettle leaves have any specific value in themselves or whether they simply keep away interfering hands by virtue of their stings.

[1] Wilson, *loc. cit.* [2] Pratt, *loc. cit.*

CHAPTER XIII.

POPULAR AND LOCAL NAMES OF WEEDS.[1]

Achillea millefolium, *L.*—Arrow-root, bloodwort, camil, cammock, carpenter-grass, devil's nettle, dog daisy, eerie, garwe, girs (stanch or stench), greenarrow, hundred-leaved grass, melefowr, milfoil, nosebleed, old man's mustard, pepper (old man's, wild), sanguinary, sneeze-wort, tansy, thousand-leaf, thousand-leaved clover, yallow, yarrow, yarroway, yerrow.

Aethusa cynapium, *L.*— Ass-parsley, dill, dog-poison, dog's parsley, false parsley, fool's cicely, fool's parsley.

Agrimonia eupatoria, *L.*—Agrimony, church-steeple, cockle burr, egremoine, egremounde, garclive, goosechite, harvest lice, hemony, liverwort, rat-tail, tansy (white, wild).

Agropyron repens. See *Triticum repens.*

Agrostis sp.—Cloud grass.

Agrostis alba, *L.*—Dun John, quick, spear grass, whicks, wicks, fine John, fiorin, running twitch, white bent grass.

Agrostis stolonifera, *L.*—Bent grass, black grass, black-top grass, fiorin-grass, knotgrass, orcheston grass, orchis grass (?), quitch, red robin, squitch grass, surface twitch, water-grass.

Agrostis vulgaris, *L.*—Bent, bent-grass, black quitch, bread-and-cheese, fine John, monkey's grass, squitch, tussocks, twitch, water twitch.

Aira caryophyllea, *L.*—Mouse-grass, hairgrass, silver hair-grass.

Aira caespitosa, *L.*—Bent grass, benton pry, bull-faces, bull-front, bull-hassocks, bull-pates, bull pole, bull's forehead,

[1] Many of the names given in this chapter have been met with in the course of the weed surveys made by the author in different parts of the country. The majority, however, have been taken from

(*a*) Britten, J., and Holland, R. (1886), "A Dictionary of English Plant Names";

(*b*) Prior, R. C. A. (1879), "On the Popular Names of British Plants".

bull-toppin, carnation-grass, flag (?), hassock, huff-caps, iron grass, sniddle, sniggle-grass, snizzle-grass, tufted hairgrass, tussock grass, windlestraws, zedge-mocks.

Ajuga reptans, *L.*—Bugle, brown bugle, dead men's bellows, herb carpenter, helfringwort, middle comfrey, middle consound, sicklewort, wild mint, wood betony.

Alchemilla arvensis, *L.*—Argentill, bowel-hive, breakstone, colickwort, firegrass, lady's mantle, parsley breakstone, parsley pert or piert, parsley vlix, percepier.

Alchemilla vulgaris, *L.*—Bear's-foot, dewcup, duck's-foot, great sanicle, lady's mantle, lamb's foot, lion's foot, padelion, pedelyon, syndau.

Allium ursinum, *L.*—Bear's-garlic, buckrams, crow-garlick, cow-garlick, devil's posy, garlick, gipsy onions, hog's-garlick, ramps, rams, ramsden, ramsey, ram's horns, ramsons, rommy or roms, rosems, stink plant, wild garlick, wild leek.

Allium vineale, *L.*—Crow onion, garlick (cow, crow, wild).

Alopecurus agrestis, *L.*—Bennet-weed, black bent, black couch, black-grass, black quitch, black squitch grass, grass (spear, twitch), hunger-grass, hunger-weed, land-grass, mouse-tail, slender fox-tail.

Alopecurus geniculatus, *L.*—Black-grass, blue-grass, elbowit-grass, flote-grass, marsh foxtail.

Anagallis arvensis, *L.*—Bird's eye, bird's-tongue, female pimpernel (var. *cærulea*), John-go-to-bed-at-noon, male pimpernel, merecrop, orange lily pernel, pimpernel, poor man's weather-glass, shepherd's calender, shepherd's clock, shepherd's delight, shepherd's glass, shepherd's sundial, shepherd's warning, shepherd's watch, shepherd's weatherglass, sunflower, tom pimpernowl, waywort, weather glass, wincopipe, wink-a-peep.

Anthemis arvensis, *L.*—Corn chamomile, dog's camomile (?), white gowlan.

Anthemis cotula, *L.*—Balder brae, baldeyebrow, camomile (dog's or stinking), camovyne, daisy (dog or horse), dog-banner, dog-binder, dog-fennel, dog-finkle, flowan, hog's fennel, jayweed, madder, madenwede, maise, maithen, mather, marg, mathes, mayweed, morgan, murg, poison daisy.

Anthriscus sylvestris, *Hoffm.*—Ass-parsley, badman-oatmeal, bun, caxes, chervil (cow-weed, mock or wild), cicely, cis-weed, coney-parsley, cow-mumble, cow-parsley, cow-weed,

da-ho, deil's meal, deil's or devil's oatmeal, devil's parsley, dill, dock (kadle or kettle), dog-parsley, eltrot, ha-ho, hare parsley, hemlock, hi-how, humlock, keck, kedlock, kee-shion, kelk or kelks, kellock, kesk, kewsies, mayweed, naughty man's oatmeal, orchard weed, parsley (dog's, pig's, sheep's, wild), rabbit-meat, ratsbane, sweet ash, white-weed, wild carraway, wild cicely.

Anthyllis vulneraria, L.—Cat's-claws, crawnels, Jupiter's beard, kidney vetch, lady's fingers, luck, lamb's-toe, rustic wound-wort, staunch, woundwort, yellow crow's-foot.

Antirrhinum orontium, L.—Calf-snout.

Arabis thaliana, L.—Thale-cress, wall-cress.

Arenaria.—Sandweed, sandwort.

Arenaria serpyllifolia, L.—Chickweed, thyme-leaved sandwort.

Arnoseris pusilla, Gaertn.—Lamb's succory, swine's succory.

Arrhenatherum avenaceum, var. tuberosum, Gilib.—Arnit or arnut, buckbeards, button-grass, couch, haver-grass, knot-grass, lobbin grass, lousy or lucie arnut, murrick, onion couch, pearl, pearl grass, quitch, swine arnut, twitch (butter or button).

Artemesia vulgaris, L.—Apple-pie, bulwand, fat hen, fellon-herb, French tobacco, green ginger, mogford, motherwort, muggert, mugweed, mugwort, sailor's tobacco, smother-wood, weremod, wormwood, wormit.

Atriplex.—Areche, blite, meals, wild orach.

Atriplex patula, L.—Arach, delt-orach, fat hen, lamb's quarters.

Avena fatua, L.—Bearded oat, drake, flaver, haver, Kentish longtails, poor oats, sowlers, uncorn, wild aits, wild oat.

Bartsia odontites, L.—Eyebright, eyebright cow-wheat, hen gorse, red rattle, sanctuary.

Bellis perennis, L.—Bachelor's buttons, bairnwort, banwood, banwort, bennergowan, bennert, bennet, benwort, bessy-banwood, billy button, boneflower, bonwort, briswort, bruisewort, catposy, cockiloorie, comfrey, confery, cumfirie, daiseyghe, daisy, daisy (dog, shepherd's, small or the children's), dazeg, dicky daisy, ewe-gowan, gowan, gowlan, hen and chickens, herb margaret, less consound, March daisy, margaret's herb, May gowan, Mary gowlan, marguerite, maudlinwort, mother of thousands, primrose, silver penny, sweep, sweeps.

Borago officinalis, L.—Beebread, borage, burrage, cool-tankard, Langdebeef, ox-tongue, star flower.

Brassica alba.—Charlock, kedlock, kellock, kerlock, ketlock, senvie, white mustard.

Brassica campestris, L.—Bargeman's cabbage, charlock, ketlock, nape, yellows.

Brassica sinapis.—Bastard rocket, bazocks, birdseed, brassics, brassock, cadlick, cadlock, callock, calves-feet, carlock, chadlock, charlick, charlock, chedlock, churlick, corn cale, craps, curlick, curlock, field kale, garlic, garlock, kadlock, kale, kecklock, kedlock, kellock, kerlock, ketlock, kilk, kinkle, mustard (corn, wild), popple, presha, or preshabhwee or prushus, rape, rough cadlock, runch, rungy, scaldrick scalies, scallock; senvie, shirt, skedlock, skeldock, skeldick, skellock, skellie or skillock, turnip, warlock, will kail, wild kale, yellow flower.

Briza media, L.—Amouret, bird's-eye, cow-quake, dadder-grass, danglethorn (?), dawther, didder-grass, diddery-docks, dithering-grass, dodder, dodder-grass, doddering-dickies, doddering-dillies, doddering-grass, doddering-jockies, dodderin-Nancy, doddle-grass, dothering-dicks, dothering-toms, earth-quakes, grass (fairy, pearl, quaker, rattle, shaking, shiver, shivering, swaggering, totter, tottering, trembling, waggering), hay shakers, jockey grass, lady's hair, maiden-hair, mountain flax, quack-ducks, quakers, shake ladies, shakers, shivering jemmy, sillar shakle, siller tassels, silver ginglers, silver shakers, suisilk, trembling jockies, thrimlin-jockies, wag-wanton, wag-wants, whacker gerse, wiggle-waggles, wig-wag wanton, wiggle-waggle-wantons.

Bromus arvensis, L.—Field brome.

Bromus asper, L.—Hairy brome.

Bromus mollis, L.—Blubber-grass, bob-grass, bull-grass, cock-grass, darnel, duck havver, geese-grass, goose corn, goose-grass, haver-grass, hooded grass, lob or lob grass, oat-grass.

Bromus secalinus, L.—Cheat, cheats, ches-seed weed, cock-grass, darnel, drake, droke, drook, oat (dravick, wild), rye brome-grass, sleepies.

Bromus sterilis, L.—Black-grass, drake, drank, haver-grass, oat-grass.

Calamintha acinos, Clairv.—Basil (field, stone, or wild), basil balm, basil thyme, corn mint (?), mother of thyme, poley mountain.

Camelina sativa, Cr.—Camline, cheat, Dutch flax, gold of pleasure, myagrum, oil-seed.

Capsella bursa-pastoris, L.—Bad man's oatmeal, blind-weed, case-weed, clappedepouch, cocowort, fat hen, lady's purse, mother's heart, naughty man's plaything, pepper-and-salt, pick-pocket, pick-purse, pick-your-mother's-heart-out, poor man's parmacetty, sanguinary, shepherd's bag, shepherd's pouch, shepherd's purse, shepherd's scrip, tooth-wort, toywort, ward-seed, witches' pouches.

Cardamine pratensis, L.—Apple-pie, bird-eye, bird's-eye, bitter cresses, bogspinks, bonny-bird-een, bread-and-milk, canterbury bells, cuckoo, cuckoo-bread, cuckoo-flower, cuckoo-pint or pintle, cuckoo-spit, cuckoo's shoes and stockings, gookoo-buttons, gookoo-flower, headache, impatient cress, lady flock, lady's glove, lady's milksile, lady's smock, lamb lakins, lucy locket, may blob, may flower, meadow, meadow cress, medetarde, milkgirl, milkmaid, milksile, paigle, pigeon's eye, pig's eyes, pink, shoes and stockings, smell smock, smick smock, spink, whitsuntide gilliflower.

Carduus nutans, L.—Queen Ann's thrissel, thistle (bank, buck, dog, musk, Scotch).

Carex.—Ae-pointed-gairss, carnation-grass, cegge, grass (blue, hard, spear, sour, spire, star, sword), lesch, ling, moor-pawms, pry, rush, sag, sedge, seggin, seggs, serge, sniddle, zeg.

Carex glauca, L.—Carnation-grass, gilliflower-grass, glaucous sedge, grass (pigeon's, pink), pry.

Carex hirta, L.—Carnation-grass, goose-grass, hairy sedge, hammersedge.

Carex vulpina, L.—Fox sedge.

Caucalis nodosa, Scop.—Knotted hedge parsley.

Centaurea nigra, L.—Bachelor's buttons, ballweed, belweed, black centaury, black soap, blue tops, boleweed, bolwes, bowweed, bowwood, bullweed, bunds, bundweed, bunk, button-weed, centaury, centaury (great or more), churl's-head, clobweed, club-weed, cnop-wort, cock-heads, cod-weed, crop-weed, darbottle, drumstick, hardhead, hardhead horse, hard-iron, hare-bottle, harsh-weed, horse hardhead, horse knobs, horse knops, horse knot, horse-snap, hurt-sickle, hyrnehard, iron-heads, iron-weed, knapweed, knob-weed, knop-weed, knotgrass, knotweed, lady's cushion, loggerheads, matfellon, shaving-brush, sweeps, tarbottle, tassel, yronhard.

Centaurea scabiosa, L.—Bachelor's buttons, black-top, bowwood, bunk, drumstick, great horse knobs, great knapweed, horse knobs, horse knops, iren-harde, knobweed, knotweed, matfellon.

Cerastium vulgatum, L.—Chickweed, mouse-ear, mouse-ear chick-weed.

Chenopodium.—Goose-foot, meals, nightshade, wild orach.

Chenopodium album, L.—Biacon-weed, dirtweed, dirty Dick, dirty John, drought-weed, fat hen, frost-blite, hen-fat, Johnny O'Neele, lamb's-quarters, lamb's-tongue, mails, meldweed, melgs, midden myles or milies, milds or miles, muck-weed, mutton-tops, myles, rag jag, wild spinach (pigweed in Canada and U.S.A.).

Chrysanthemum leucanthemum, L.—Bozzom, caten-aroes, cows' eyes, daisy (big, bull, butter, devil's, dog, dun or dunder, field, great, horse, London, midsummer, moon, ox-eye, poor-land, thunder), daisy goldins, dog-flower, Dutch morgan, espibawn, gadgevraw, gadjerwraws, girt ox-eye, goode, gowan (horse, large, white), horse-pennies, hoss-daisy, large dicky daisy, magweed, maudlinwort, may-weed, moon, moon-flower, moon-pennies, moon-penny, moonwort, ox-eye, poverty weed, white bothen, white gold, white gowlan, white gull.

Chrysanthemum segetum, L.—Bigold, boodle, boswell, bothem, bothen, botherum, bothul, bozzom, buddle, budland, corn marigold, fat hen, geal gowan or geal seed, gil gowan, gold, golden corn-flower, golding, goldings, goles, golland, gool or goold, gould, gouls, gowan (gule, yellow), gowlan, gowland, guild, guile, gule, manelet, marigold, marigold (field, wild), marigold goldings, marigold goldins, moon or moons, ox-eye, ruddes, sunflower, tansy, yellow bottle, yellow gold, yellow gowans, yellow gull, yellow ox-eye.

Cichorium intybus, L.—Bunk, chicory, succory, wild cicory.

Cirsium acaule, Web.—Dwarf thistle, ground thistle, pod-thistle, stemless thistle.

Cirsium arvense, Scop.—Creeping thistle, dashel, dodger, thistle (boar, corn, cursed, dog, hard, pricky, sharp, way).

Cirsium lanceolatum, Scop.—Bow fistle, bur, cheese, dashel, marian, quat vessel, thistle (bank, bell, bird, blue, boar, buck, bull, bur, horse, Scotch, spear).

Cirsium palustre, Scop.—Bog-thrissel, marsh thistle, moss-thistle, thistle (red, water).

Colchicum autumnale, *L.*—Crocus (autumn, fog, meadow, michaelmas, purple), meadow saffron, naked boys, naked lady, naked virgins, rams, saffron, son-before-the-father, star-naked boys, tube root, upstart.

Conium maculatum, *L.*—Bad man's oatmeal, bunk, cambuck, caxes, heck-how, hemlock, herb bennet, humlock, humly, keck, kex, kelk, kous, keish, kewse, St. Bennet's herb, wode-whistle.

Conopodium denudatum, *Koch.*—Arnit or arnut, badman's bread, catnut, cipper-nut, curluns, deil's bread, deil's oatmeal, dil-note (?), earth chestnut, earthnut, ernut, fare-nut, gennet, gernut, gourlins, gowlins, grunnut, hawk-nut, hog-nut, hornecks, Jack durnils, jocky jurnals, jurnut, killas, killi-more, kipper-nut, knipper-nut, knotty meal, lousy or lucie arnut, mandrake, nut (ground, hare, kipper, pig, St. Anthony's), scabby hands, swine-bread, tetter-berry, truffle, yannut, yarnut, yennet, yennut, yenut, yor-nut, yer-nut, yowe yorlings.

Convolvulus arvensis, *L.*—Barbine, barweed, bearbind, bell-bine, bellwine, billy-clipper, bindweed, bine, common bind, corn-bind, corn-lily, devil's guts, gravel bindweed, hedge bells, lap-love, lily, lily-bind, rope-wind, sheep-bine, small bindweed, small withiwind, wave-wine, waywind, weed-bind, weedbine, wheatbine, wild convolvulus, wind, wither-wine, withwind or withwine.

Crepis taraxacifolia, *Thuill.*—Beaked hawk's-beard.

Crepis virens, *L.*—Smooth hawk's beard.

Cuscuta.—Devil's guts, dodder, dother, fordboh, laced thyme, strangle-weed.

Cuscuta europæa, *L.*—Beggarweed, bind, devil's guts, hailweed, hairweed, hale-, hell-, or hairy-bind, hale-weed, podder, scald, scald-weed, strangle-tare.

Cuscuta trifolii, *Bab.*—Ail-weed, beggar-weed, Indian grass.

Daucus carota, *L.*—Bee's-nest, bird's-nest, crow's-nest, dawke, dill, fiddle, field more (?), hill-trot, mirrot, rantipole, wild carrot.

Echium vulgare, *L.*—Blue bottle, blue weed, blue cat's-tail, bugloss, cat's-tail, iron-weed, langdebeef, our Lord's flannel, our Saviour's flannel, snake flower, snake's bugloss, viper's bugloss, viper's grass, viper's herb, wild borage.

Epilobium.—Herb willow, willow herb.

Epilobium hirsutum, *L.*—Apple-pie, blooming sally, cherry-pie, coddled apple, codlins, codlings-and-cream, custard-

cups, fiddle-grass, gooseberry pie, plum-pudding, red withy herb, sod-apple, son-before-the-father, wild willow, willow herb.

Equisetum.—Cat-rushes, cat's-tail, feather, grandfather's beard, grass (joint, scrub, shave, water), holy-water-sprinkle, horse-tail, joint-weed, mare's-tail, old man's beard, puddock pipes, pull pipes, rattle, snake pipes, tad-broom, tad pipes, tidy-pipe, toad pipe, wold man's beard (?).

Equisetum arvense, L.—Bottle-brush, cat's-tail, colt's-tail, frog pipes, horse pipe, scrub grass, shave grass, snake pipes.

Erigeron canadense, L.—Butter-weed, Canadian fleabane.

Erodium.—Heron's-bill.

Erodium cicutarium, L'Her.—Needle (pink, powk), stick-pile, stork's-bill, wild musk.

Erysimum cheiranthoides, Br.—Tarrify, treacle mustard, treacle wormseed, worm-seed.

Euphorbia.—Spurge, tithymall.

Euphorbia exigua, L.—Dwarf spurge.

Euphorbia helioscopia, L.—Cat's-milk, churnstaff, deil's apple-trees, deil's kirn staff, deil's milk, devil's churnstaff, devil's milk, grass (wart, whitlow), irby-dale grass, little good, mad woman's milk, mamma's milk, milk wort, milk-weed, mouse-milk, Saturday's pepper, seven sisters, sun spurge or sun-following spurge, turnsole or torn-sole, wartweed, wortwort, wolf's milk.

Euphorbia peplus, L.—Deil's milk, devil's milk, petty spurge, seven sisters, wartweed, wee gweedie.

Euphrasia officinalis, L.—Adhib, euphrasy, ewfras, eyebright.

Filago germanica, L.—Cartafilago, chafeweed, childing cud-weed, clodweed, cudweed, cudwort, downweed, herb impious, hoarwort, old owl, owl's crown, quidwort, son-before-the-father.

Fumaria officinalis, L.—Beggary, earth-smoke, fume-of-the-earth, fumiterre, fumitory, fumusterre, God's fingers and thumbs, snapdragon, wax dolls.

Galeopsis tetrahit, L.—Bee-nettle, blind-nettle, dai-nettle, day-nettle, dea-nettle, de-nettles, deye-nettle, dog-nettle, don-ninethell, female hems, glidewort, hemp (bastard, nettle, wild), hemp-nettle, holyrope, stinging nettle, sting nettle.

Galium aparine, L.—Airess, airif, airup, aparine, bedstraw, beggar lice, beggar weed, bleedy tongues, bluid tongue, bur, burhead, burweed, catch-rogue, catch-weed, chick-weed, claiton, claver-grass, cleavers, cledon, cleeiton,

cleggers, clever-grass, cliden, clider, cling-rascal, clitch-button, clite, clitheren, clits, cliver, cly, clyders, errif, geckdor, geese-grass, gentlemen's tormentors, goosebill, goose-grass, goose-heiriffe, gooseshare, goose tongue, gosling grass, gosling scrotch, gosling weed, grass (scratch, scurvy, Turkey), grip-grass, gull-grass, gye, hairweed, harif, haritch, harvest lice, hedge-burs, Jack-at-the-hedge, Lizzie-run-the-hedge, Loveman, mutton-tops, pig-tail, Robin-run-the-hedge, Rob-run-up-dyke, scratch-weed, soldiers' buttons, stick-a-back, stickleback, sweethearts, tivers, tongue-bleeder, witherspail, Willy-run-hedge.

Galium tricorne, Stokes.—Rough-fruited bedstraw.

Galium verum, L.—A-hundred-fald, bedflower, bedstraw (lady's or yellow), brum, cheese-rennet, cliver, curdwort, fleaweed, fleawort, gallion, hundred-fold, joint grass, keeslip, lady's beds, maiden-hair, maid's hair, our ladies' bedstraw, petty mugwet, rennet, runnet, strawbed, wild rosemary, yellow goose-grass.

Genista tinctoria, L.—Alleluia, base broom, broom (dyers' or low), dyers' greening weld, dyers' weed, dyers' green-weed, dyers' yellow-weed, dyeweed, green weed, green-wood, widow wisse, woad, woadwax, woodwax, wood waxen, wood wex, wudwise, yellows.

Geranium.—Crane's-bill, heron's-bill, shepherd's needle.

Geranium dissectum, L.—Cut-leaved crane's-bill, pink needle (?).

Geranium molle, L. — Culverfoot, dove's-foot, dove's-foot crane's-bill, pigeon's foot, soft crane's-bill, starlights.

Geranium pratense, L.—Crowfoot, crane's-bill, grace of God, gratia Dei.

Geranium pusillum, L.—Smooth crane's-bill.

Gnaphalium uliginosum, L.—Chafeweed, cotton weed, cudweed, marsh cudweed, wartwort.

Heracleum sphondylium, L. — Bear's breech, bear-skeiters, beggar-weed, bilders, billers, broad-leaved keck, broad kelk, bunnel, bunnerts, bunnun, bunwand, caddell, cad-weed, camlicks, clogweed, cow-cakes, cow-clogweed, cow-keeks, cow-keep, cow-mumble, cow-parsnip, cushia, dry kesh, dryland, scout, eltrot, ha-ho, hardhead, heltrot, hogweed, keck, kedlock, kex, keglus, kelk-kecksy, kesh, kesk, kewsies, limperscrimp, lumper-scrump, madnep, meadow parsnep, old-rot, pig's bubbles, pig's cole, pig's parsnip, pigweed, piskies, rabbit-meat, sweet biller, swine weed, skytes.

Hieracium pilosella, L.—Erswort (?), fellon-herb, ling gowlans, mouse-ear, mouse-ear hawkweed.

Holcus lanatus, L.—Dart grass, duffel grass, grass (pluff, rot, velvet, water), hose grass, hose gerse, meadow soft grass, midge-grass, pussy-cats'-tails, soft grass, white hayseeds, Yorkshire fog, Yorkshire whites.

Hordeum pratense, L.—Rie grass, squirrel-tail grass.

Hypochaeris radicata, L.—Bent, cat's-ear, gosmore.

Juncus.—Rashes, resh, rexen, rish, rix, rush, ryschys, seave, seife (?), siv, thrash, threshie, thrush, thrush-bush.

Juncus articulatus, L.—Shining-fruited rush, spart.

Juncus bufonius, L.—Coe grass, frog grass, toad grass, toad rush, saltweed.

Juncus communis, Mey.—Camel's straw, common rush, floss (?).

Juncus glaucus, Ehr.—Hard rush, resh, wire rush.

Lamium amplexicaule, L.—Chickweed, hen-bit.

Lamium purpureum, L.—Archangel (red or sweet), badman's posies, black man's posies, day nettle, dead nettle, deaf nettle, dee nettle, dog nettle, French nettle, nettle, purple dea-nettle, purple stinking archangel (?), red dead nettle, rabbit-meat, tormentil.

Lapsana communis, L.—Ballagan, bolgan-leaves, dock cress, nipple-wort, succory dock cress, swine's cress.

Lathyrus macrorrhizus, Wimm.—Bitter vetch, caperoilie, carameile, carmele, carmeil, carmile, carmylie, cormeille, corr, gnapperts, heath pea, karemyle, kipper nut, knapperts, knipper-nut, liquory-knots, mouse pea, napperty, napple, thetch, wood pea.

Lathyrus pratensis, L.—Angleberries, craw-peas, craw pea, lady's fingers, mouse pea, tare-everlasting, tom thumb, vetchling, yellow chickling vetch, yellow fitchling, yellow meadow vetchling, yellow tar fitch.

Legousia hybrida, Del.—Corn campanula, corn violet, venus looking-glass.

Leontodon autumnalis, L.—Autumnal hawkbit, garkin pissabed.

Leontodon hispidus, L.—Rough hawkbit.

Linaria elatine, Mill.—Cancerwort, cankerwort, female fluellin, pointed fluellen, speedwell.

Linaria minor, Mill.—Jack-by-the-hedge, small toadflax.

Linaria spuria, Mill.—Cancerwort, cankerwort, female fluellin.

Linaria vulgaris, Mill.—Bride-weed, butter-and-eggs, buttered haycocks, chopt eggs, churnstaff, doggies, dragon-bushes, eggs-and-bacon, eggs-and-butter, eggs-and-collops, flax

(toad, wild, yellow toad), flaxweed, gallwort, larkspur, lion's mouth, monkey flower, pattens and clogs, rabbits, snapdragon, yellow (or yaller) rod.

Linum catharticum, *L.*—Fairy flax, fairy lint, flax (dwarf, mountain, purging), laverock's lint, mill-mountains.

Lithospermum arvense, *L.*—Bastard alkanet, corn gromwell lichwale, painting root, pearl-plant, salfern.

Lizula campestris, *Willd.*—Blackcaps, chimney-sweeps, crow-feet, cuckoo grass, davie-drap, field woodrush, God's grace, Good Friday grass, grass (black-head, peeseweep), hair-beard, smuts, sweeps, sweeps' brushes, sweet bent.

Lolium temulentum, *L.*—Bragge, cheat, cockle, darnel, dornel, dragge, drake, drank, dravick, droke, drunk, drunken plant, eaver, ivray, jum, lover's steps, ray, riely, rivery, sturdy.

Lychnis alba, *Mill.*—Bachelor's buttons, bull-rattle, cockle, cow-mack, cow-rattle, cuckoo-flower (white, wild), grandmother's nightcap, plum-puddings, snake flower, snake's flower, thunder bolts, thunder-flower, white bachelor's buttons, white campion, white robin.

Lychnis dioica, *L.*—Adder's-flower, bachelor's buttons, billy button, bird's eye, brasselty-buttons, brid-een, bull's eye, cock-robin, crowsope, cuckoo, cuckoo-flower, devil's flower, flea-bites, geuky-flower, gramfer-greygles, hare's eye, jack-by-the-hedge, lousy beds, lousy soldiers' buttons, mother-dee, plum-puddings, poor robin, ragged robin, red bachelor's buttons, red bird's eye, red butcher, red campion, red jack, robin or robins, red robin, robin flower, robin hood, robin-in-the-hose, robin i' th' hedge, robin red-breast, robin's eye, round robin, scalded apple, soldiers, water poppies, wild geranium, wild rose campion.

Lychnis Flos-cuculi, *L.*—Bachelor's buttons, cock's-caim, cock's-comb, crow-flower, cuckoo, cuckoo-flower, cuckoo gilliflower, fair maid of France, Indian pink, marsh-gilliflower, meadow campion, meadow pink, meadow spink, pleasant-in-sight, ragged jack, ragged robin, robin hood, rough robin, wild williams.

Lychnis githago, *Lam.*—Bachelor's buttons, cockle, corn campion, corn cockle, cockweed, corn-flower, corn pink, drawk, field nigella, gith, gye, hardhead, nele, papple, pawple, pink, popille, popple, poppy, ray, wild savager.

Lycopsis arvensis, *L.*—Bugloss, field alkanet, sheep's tongue.

Lysimachia nummularia, *L.*—Creeping jenny, herb twopence, meadow-runagates, money-wort, motherwort, strings of sovereigns, twopence, twopenny grass, wandering jenny, wandering sailor.

Matricaria chamomilla, *L.*—Camomile (dog's, German or wild), deil's apple-riennie, dog's camovyne, horse gowan, maithe, mather, maudlin, mayweed, whitewort.

Matricaria inodora, *L.*—Camomile (dog's or unsavoury), camomile goldins, daisy (dog, horse), dog's camovyne, dog gowan, mayweed, scentless mayweed, white gowlan.

Medicago lupulina, *L.*—Black grass, black medick, black nonesuch, black seed, black trefoil, cinquefoil, clover, clover (horned or yellow), croyd, hop, hop clover, hop medick, hop trefoil, lamb's-toe, melilot trefoil, natural grass, nonesuch, sanfoin, shamrock, snail trefoil, trefoil.

Melilotus officinalis, *L.*—Clover (hart's, king's, or plaister), heartwort, king's crown, melilot, whuttle grass, wild laburnum.

Mentha aquatica, *L.*—Baulme mint (?), bishop's weed, bishop's wort, fish mint, water mint.

Mentha arvensis, *L.*—Corn mint, field mint, lamb's tongue, wild pennyroyal.

Myosurus minimus, *L.*—Bloodstrange, mouse-tail.

Mysotis arvensis, *L.*— Bird's eye, blue mouse-ear, forget-me-not.

Mysotis palustris, *L.*—Bird's eye, catter-pillars, forget-me-not, love-me, mouse-ear, scorpion grass, snake grass.

Mysotis versicolor.—Forget-me-not.

Nepeta glechoma.—Alehoof, allhoove, allhose, alliff, bird's eye, blue runner, cat's-foot, deceivers, devil's candlesticks, fat hen, foalfoot, folesfoth, gell, gill, gill-ale, gill-creep-by-ground, gill-go-by-ground, groundavey, ground ivy, hayhofe, haymaiden, hay-maids, hedge-maids, heihow, hen and chickens, heyhove, hove, jenny-run-ith-ground, jill, lion's mouth, lizzie-run-the-hedge, maiden-hair, mould, nip, robin-run-the-hedge, rob-run-up-dyke, run-away-jack, runnidyke, tudnoore, tunhoof, turnhoof.

Œnanthe pimpinelloides, *L.*—Earth-nut, pig-nut.

Ononis arvensis, *L.*—Bomariskie, cammock, cammock whin, cat whin, chamock, fin, finweed, ground furze, harrow rest, hen gorse, horse's breath, lady-whin, lewte, petty whin, ramsey, rastylbow, rassels, rest-harrow, rust-burn, sidfast, sitfast, Spanish root, stainch, stay-plough, stinking tam, wild liquorice.

Orchis maculata, *L.*—Adam-and-eve, adder's grass, baldberry, crawfoot, crowfoot, dead man's fingers, dead man's hands, hand orchis, hens, hen's combs, lover's wanton, man orchis, nightcap, red-lead, spotted orchis.

Orchis mascula, *L.*—Aaron's beard, Adam-and-Eve, adder's-grass, adder's-tongue, ballock grass, beldairy, bloody butchers, bloody fingers, bloody man's finger, bloody man's hands, bulldairy, bull's-bags, bull-seg, candlegostes, cling-fingers, cock-flowers, cock's kames, cowslip, crake-feet, craw-feet, crawfoot, craw-tees, cross-flower, crow-feet, crow-foot, cuckoo, cuckoo-flower, cuckoo orchis, cuckoo-pint, culverkeys, dag-stone, dead man's fingers, dead man's hand, dead man's thumb, dog's-dogger, dog-stones, drake's-feet, fool's stones, foxstones, frogwort, gandergoose, gander-gosses, gandigosling, Gethsemane, geuky-flower, giddy gander, goat-stones, goosie-gander, gowk meat, gramfer-greygles, greygles, gussets, Johnny-cocks, keatlegs, kettle case, kettle-pad, king-finger, lady's fingers, long purples, man orchis, nightcap, paddock's spindle, poor man's blood, priest's pintle, purples, rag-wort, red butcher, red granfer gregors, red-lead, ring-finger, salep, scabgowks, single castle, single-guss, skeat-legs, snake flower, soldier's jackets, spreespinkle, stander grass, stannen-gusses.

Orchis morio, *L.*—Beldairy, bleeding willow, bull's bags, bull-segg, cuckoo, cuckoo-flower, dandy goshen, dead man's fingers, fool's ballocks, fool's stones, frogwort, gander-gosses, goose and goslings, green-veined orchis, green-winged orchis, king-finger, king-fisher, man orchis, nuns, parson's nose, puddock's spindles, rams horns, red-lead, single castle.

Ornithogalum pyrenaicum, *L.*—Asparagus (Bath, French, Prussian, or wild), French grass, French sparrow-grass, sperage, spiked star-of-Bethlehem.

Ornithopus perpusillus, *L.*—Bird's-foot, fowl-foot.

Orobanche.—Broom-rape, choke-fitch, choke-weed, herb-bane, kill-herb, strangle-tare, strangle-weed.

Orobanche major, *L.*—Orobstrangler, Our Lady of New Chapel's flower, tall or great broomrape.

Papaver argemone, *L.*—Cock's head, headache, pale poppy, rough-head poppy, small poppy, wind rose.

Papaver dubium, *L.*—Blaver, blind eyes, cock's-head, headache, long-headed poppy, yedwark.

Papaver hybridum, *L.*—Rough poppy.

Papaver rhœas, *L.*—Blind eyes, blindy-buffs, bledewort, canker, canker rose, cheesebowl, chesbow, cockeno, cock-rose, cock's-comb, cock's-head, collinhood, copper-rose, coprose, corn rose, corn-flower, corn poppy, cuprose, cusk, darnel, ear-aches, fire-flout, gye, headache, headwarke, joan silverpin, lightnings, maws, poison poppy, pope, popple, poppy, puppy, redweed, ridweed, soldiers, thunder bolts, thunder flower, wild poppy, yedwark.

Pedicularis sylvatica, *L.*—Cock's-comb, dead men's bellows, honeysuckle, lousewort, red rattle.

Pimpinella saxifraga, *L.*—Bennet, breakstone, burnet saxifrage, old man's plaything, pimpernel, saxifrage, self-heal.

Plantago coronopus, *L.*—Buck's-horn, buck's-horn plantain, crow-foot, hartshorn, hartshorn plantain, herb eve, herb ive, star of the earth.

Plantago lanceolata, *L.*—Bent, black bent, black jacks, carl-doddie, chimney-sweeps, clock, cock-fighters, cocks, cocks-and-hens, cock's-head, curl-doddy, dog's-rib, grass (cock, rib, ripple), hardhead, headman, jackstraws, kemps, kempseed, knockheads, lamb's-tongue, lancell, leechwort, long plantain, plantain, ramstongue, rat-tail, rib-wort, rib-wort plantain, soldiers, soldier's tappie, tinker-tailor grass, windles.

Plantago major, *L.*—Bent, birdseed, bird's meat, broad leaf, canary-seed, carl-doddie, curl-doddy, great plantain, great waybrede, healing blade, kemps, lamb's-foot, plant, plantain, rat-tail, ripple girs, slanlas, warba leaves, wabert-leaf, wayberan-leaf, waybread, wayfaring leaf, wayfron, wayside bread, waybred, white man's footprint, wibrow, wybrow.

Plantago media, *L.*—Fire-leaves, fire-weed, healing herb, hoary plantain, lamb's-tongue.

Poa annua, *L.*—Annual meadowgrass, cause-way grass, Suffolk grass.

Polygala vulgaris, *L.*—Cross-flower, four sisters, gang flower, milkwort, procession flower, robin's eye, rogation flower.

Polygonum aviculare, *L.*—Allseed, armstrong, beggar-weed, bird's knotgrass, bird's-tongue, black strap, bloodwort, centinode, cow grass, crab grass, crab-weed, cumberfield, doorweed, finzach, grass (iron, knot, pig, swine's, wire), hogweed, knotgrass, knotwort, mantie, nine joints, ninety-knot, pig-rush, pig-weed, pink-weed, red-legs, red robin, redweed, sparrow-tongue, stone-weed, surface twitch,

swine-carse, swine's skir, tacker-grass, way-grass, wire-weed.

Polygonum convolvulus, *L.*—Bearbind, bedwine, bethwine, bindcorn, bindweed, bindweed (black, corn, or ivy) black withiwind, bunwede, climbing buckwheat, cornbind, devil's tether, dodder, hay-gob, lap-love, lily, spades, weedwind, wild hop, windweede, withwind, withwine.

Polygonum lapathifolium, *L.*—Pale willow-weed, willow-weed.

Polygonum persicaria, *L.*—Crab grass, crab's claw, cronesanke, dead arsesmart, lakeweed, lover's pride, morub, peach-wort, persicaria, red legs, red shank, red-weed, sauch-weed, saucy Alice, spotted arsesmart, Virgin Mary's pinch, willow-weed.

Potentilla anserina, *L.*—Argentina, argentine, blithran, butter-cup, camoroche, fair days, fair-grass, goose-grass, goose tansy, helde, marsh corn, mascorns, midsummer silver, moor-grass, moors moss-crops, silver feather, silver-weed, silvery cinquefoil, tansy, tansy (dog's, wild), traveller's ease, wild agrimony.

Potentilla reptans, *L.*—Cinquefoil, fiflef, five-finger-blossom, five-finger-grass, five-fingers, five-leaf, five-leaved grass, golden-blossom, herb five-leaf, sinkfield, synkefoyle, tor-mentil.

Potentilla tormentilla, *Sibth.*—Biscuit, blood-root, earth bark, ewe daisy, five-fingers, flesh-and-blood, septfoil, setfoil, seven-leaves, shepherd's knot, shepherd's root, sheep's knapperty, thormantle, tormentil, turmentille.

Poterium sanguisorba, *L.*—Burnet, pimpernel, pimpinell, salad burnet.

Primula veris, *L.*—Artetyke, bird's-eye, cooslip, coostropple, couslop, cow-paigle, cowslap, cowslek, cowslip, cowslip primrose, cowslop, cow's-mouth, cow-paigle, cow-stripling, cow-stropple, crewel, culverkeys, fairy cups, galligaskins, gaskins, herb paralysy, herb Peter, horse buckles, lady's fingers, lady keys, may flower, paigle, palsywort, paraly-sis, passwort, Peter, petty mullein, plaggis, plum-rocks, St. Peterwort.

Prunella vulgaris, *L.*—All-heal, brown-wort, brunel, bumble bees, carpenter (herb, proud), carpenter-grass, carpenter's herb, fly flowers, heart of the earth, hook-heal, London bottles, pick pocket, pimpernel, prince's feather, prunell, self-heal, sicklewort, slough-heal, touch and heal.

Ranunculus acris, *L.*—Bachelor's buttons, baffiners, bassinet,

blister-plant, bolt, butter creeses, buttercup, butter daisy, butter-flower, butter rose, carlock-cups, clovewort, cowslip, craw-foot, craw-taes, crazy, crow-flower, crow-foot, crow-pightle, crow's-foot, crowtoe, eggs-and-butter, gil-cup, gold crap, gold cup, gold knops, golden knobs, goldy knob, guilty-cup, horse gold, king-cup, king's knob, paigle, yellow bachelor's buttons, yellow caul, yellow crees, yellow cups, yellow gowan, yellow gowlan.

Ranunculus arvensis, L.—Corn buttercup, crow-foot (corn or urchin), crow's-claws, devil-on-all-sides, devil-on-both-sides, devil's claws, devil's coach wheel, devil's currycomb, dill-cup, English stavesacre, forking robin, gold-weed, gye, hard-iron, hedge-hog, hellweed, horse gold, horse-gould, hunger-weed, Jack-o'-both-sides, jack-weed, joy, peagle, pricklebacks, scratchbur, starveacre, yellow crees, yellow cup.

Ranunculus bulbosus, L.—Baffiners, bassinet, bolt, buttercup, butter creeses, butter daisy, butter-flower, carlock-cups, craw, craw-crowfoot, crazy, crow-flower, crowfoot, crow-pightle, crow's-foot, crowtoe, cuckoo-buds, eggs-and-butter, gil-cup, gold crap, gold knobs, golden knobs, golden cup, goldy knob, guilty-cup, hillcups, horse gold, king-cob, king-cup, king's knob, lode-wort, paigle, pissabed, rape crowfoot, St. Anthony's rape, St. Anthony's turnip, yellow crees, yellow caul, yellow cups, yellow gowlan.

Ranunculus hirsutus, Curtis.—Pale hairy crowfoot.

Ranunculus repens, L.—Baffiners, bassinet, bolt, butter creeses, buttercup, butter daisy, butter-flower, carlock-cups, cat-claws, craw-foot, craw-taes, crazy, creeping buttercup, crow-feet, crow-flower, crow-foot, crow-pightle, crow's-claws, crow's-foot, crow-toe, devil's guts, gold-balls, gold crap, gold knops, golden cup, goldy knob, granny-threads, guilty-cup, hod-the-rake, horse gold, king-cup, lantern leaves, meg-many-feet, paigle, ram's claws, sitfast, sitsicker, tether-toad, toad-tether, yellow-caul, yellow crees, yellow cups, yellow gowlan.

Raphanus raphanistrum, L.—Cadlock, charlock, charlock (jointed or white), crawps, curlock, kedlock, kellock, ketlock, rabone, rump, runch, skeldock, skeldick, skellie, skellock, skillock, warlock, wild mustard, wild radish.

Reseda lutea, L.—Base dyer's weed, base rocket, crambling rocket, wild mignonette, yellow reseda.

Rhinanthus crista-galli, L.—Clock, cock-grass, cock's-comb, cow-wheat, dog's siller, fiddle-cases, gowk's sixpence, grass (penny, rattle), hen pen, henny penny, hen's combs, honeysuckle, horse pens, locusts, meadow rattle, money, money grass, pence, penny rattle, penny weed, rattle, rattle-bags, rattle-box, rattle-penny, rochlis, rottle-penny, snaffles, yellow meadow lousewort, yellow rattle.

Rumex.—Dock, docken, doodykye, phorams or phorans, red dock.

Rumex acetosa, L.—Bread-and-cheese, cock sorrell, dock (sharp or sour), donkey's oats, French sourock, green-sauce, green sorrell, lammie sourrocks, ranty-tanty (?), red shank, sallet, sarock, sooracks, sorrel, sorrel (green, sow), sorrow, sourack, sour docken, sour grass, sour leek, sour-sabs or sour-suds, sour sauce, sour sodge, sourocks, Tom Thumb's thousand fingers.

Rumex acetosella, L.—Bread-and-cheese, cuckoo's meat, cuckoo's sorrel, lammie sourocks, ranty-tanty, sheep's sorrel, sheep's sourack, sooracks, soorocks, sourocks, sour dock, sour leek.

Rumex conglomeratus, Murr.—Clustered dock.

Rumex crispus, L.—Curled dock, dockum.

Rumex obtusifolius, L.—Batter dock, broad dock, butter dock, celery-seed, cushy-cows, docken, kettle dock, red shank, smair dock.

Rumex sanguineus, L.—Bloodwort, bloody dock, dock.

Scabiosa arvensis, L.—Bachelor's buttons, billy button, black soap, blue buttons, blue caps, blue men, broadweed, cardies, clod-weed, clog-weed, curl-doddy, Egyptian rose, gipsy flower, gipsy rose, lady's cushion, pincushion, scabious, scabridge, scabril.

Scabiosa succisa, L.—Bachelor's buttons, blue-ball, blue-bannets, blue bonnets, blue buttons, blue-caps, blue-heads, blue-kiss, blue-tops, bunds, bundweed, carl-doddie, curl-doddy, devil's-bit, devil's-bit scabious, fire-leaves, forbete, forebit, forebitten more, gentlemen's buttons, hardhead, hog-a-back, lamb's ears, more-herbyw, ofbit, remcope, stinking Nancy, woolly hardhead.

Scandix pecten, L.—Adam's needle, beggar's needle, chervil (needle or wild), clock-needle, comb (lady's, shepherd's, or venus's), coombs, crake-needle, crow-needle, crowpecks, deil's or devil's darning-needle, darning needles, deil's elshin, elshins, ground enell, hedge-hog, needle, old

wife's darning needles, old woman's needle, pink needle, poke needle, pook needle, poukenel, pound needle, powk needle, puck needle, shepherd's needle, stikpyle, tailor's needles, throck-needle, venus'-needle, wild parsley.

Scleranthus annuus, *L.*—German knotgrass, knawel, knotgrass, parsley pert or piert.

Senebiera coronopus, *Poir.*—Buck's-horn, cress (swine's or wart), grass (hog, sow), hartshorn, herb Eve, herb ive, star of the earth, wartwort.

Senecio jacobæa, *L.*—Agreen, benweed, bindweed, binweed, booin, bowens, bowlochs, bunnels, bunwede, cammock, cankerweed, cheadle-dock, cowfoot, cradle-dock, cushag, dock (kadle, kettle), dog-standard, fairies' horse, fellon-weed, fizz-gigs, fleedod, fleenurt, flydod, grundswaith, James' weed, James' wort, keddle dock, marefart, muggert, ragged Jack, ragged Robin, rag weed, rag wort, St. James' wort, scrape-clean, seggrom, seggy, sigrim, stagger-wort, staner-wort, staver-wort, stinking alisander, stinking Billy, stinking Davie, stinking elshinder, stinking-weed, swine's cress, swine's grass, tansy, weeby, yack-yard, yark-rod, yellow ellshinders, yellow-weed.

Senecio vulgaris, *L.*—Birdseed, chickenweed, chinchone, grinning swallow, grinsel, groundsel, grunsel, grundsel, grunnishule, sencion, simson, swichen.

Serratula tinctoria, *L.*—Saw-wort.

Sherardia arvensis, *L.*—Allison, dodger, field madder, herb sherard, madderlen, spurwort.

Silene anglica, *L.*—English catchfly.

Silene inflata, *L.*—Adder-and-snake plant, ben, bird's-eggs, bladder campion, bletherweed, bull rattle, clapweed, cowbell, cowcracker, cowmack, cowpaps, crackers, frothy poppy, knap-bottle, rattle-bags, snappers, spatling poppy, thunder bolts, white bottle, white cockle.

Silene noctiflora, *L.*—Night-flowering catchfly.

Sisymbrium officinale, *L.*—Bank cress, crambling-rocket, hedge mustard, hedgeweed, lucifer matches, scrambling rocket.

Solanum dulcamara, *L.*—Awf'ood, belladonya, bittersweet, blue bindweed, deadly nightshade, dogwood, dwale, fellon-wood, fellonwort, mad dog's berries, nightshade (bittersweet, wood), poison-berry, poison-flower, poisonous tea plant, pushion berry, robin-run-the-hedge, skaw-coo, snake-berry, snake's poison-food, sweet bitter, terri-diddle, terrydivle, tether devil, woody night-shade.

Solanum nigrum, *L.*—Black nightshade, duscle, garden nightshade, hound's-berry, mixplenton, morel, petty morel.

Sonchus arvensis, *L.*—Corn sowthistle, dindle, gutweed, hogweed, rosemary, swine thistle, tree sow thistle, langley beef.

Sonchus oleraceus, *L.*—Dindle, hare's colewort, hare's lettuce, hare's palace, hare's thistle, milk thistle, milk-weed, milky dashel, milky dickles, milky tassel, St. Mary's seed, sowdingle, sow thistle, swine thistle, swinies, thowthystylle.

Spergula arvensis, *L.*—Beggar-weed, bottle brush, cowquake, dodder, dother, farmer's ruin, franke, granyagh, lousy grass, make-beggar, mountain flax, perry, pick pocket, pick purse, poverty weed, sandgrass, sandweed, spurry, toad flax, yarr, yarrel, yawr, yur.

Spiræa filipendula, *L.*—Dropwort, fillyfindillan, lady's ruffles, meadow-sweet, walwort (?).

Spiræa ulmaria, *L.*—Bittersweet, bridewort, courtship-and-matrimony, goat's beard, harif, honey-sweet, maid of the meadow, maid-sweet, meadow-soot, meadow-sweet, meadwort, my lady's belt, queen-of-the-meadow, sweet hay.

Stachys arvensis, *L.*—Field woundwort.

Stachys betonica, *Benth.*—Betayne, betony, bidney, bishopswort, Vetoyn, wild hop, wood betony.

Stachys palustris, *L.*—Clown's all-heal, clown's woundwort, cock-head, dead-nettle, hound's-tongue, marsh woundwort, rough weed, runch, sheep's brisken, swine arnut, swine's maskert.

Stellaria graminea, *L.*—Heath speedwell, star-wort.

Stellaria medea, *L.*—Chickenweed, chickenwort, chickweed, chuckenwort, cickenwort, craches, cuckenwort, flewort, hen's inheritance, maruns, tongue grass, white bird's-eye, winter-weed.

Taraxacum vulgare, *Lam.*— Bitterwort, blowball, blower, canker, cankerwort, clock, crow-parsnip, dandelion, dentelion, dindle, doon-head-clock, fortune-teller, gowan (horse, witch, yellow), grumsel, Irish daisy, lion's teeth, male, milk gowan, monkshead, one-o'clocks, pee-a-bed, pismires, piss-abed, priest's crown, stink davie, swine's snout.

Thlaspi arvense, *L.*—Boor's mustard, bowyer's mustard, churl's mustard, cress (penny or wild), dish mustard, mithridate mustard, treacle mustard, treaclewort.

Tragopogon pratensis, *L.* — Buck's-beard, gait-berde, goat's beard, go-to-bed-at-noon, Jack-by-the-hedge, John-go-to-

bed-at-noon, Joseph's flower, nap-at-noon, noon-flower, noontide, shepherd's clock, sleep-at-noon, star of Jerusalem.

Triticum repens, *L.* (= *Agropyron repens*, *Beauv.*). —Cooch, couch, couchwheat, dog-grass, felt, grass (cough, pearl, quick, quitch, scutch, shelly, skally, spear, squitch, three-leaved, twitch, wicken), knotgrass, lonachies, needles, quick, quicken, qwicks, quitch, rack, ronnachs, runch (?), scryle, scutch, shear grass, sheep's cheese, sheep's sourack, skoil, squitch, strap grass, stroil, twike, twitch, whickenins, whicks, white couch-grass, wick, wickens, windlestraws, wizzards, wrack, yawl.

Tussilago farfara, *L.*—Ass's foot, bull-foot, clatter-clogs, clayt, clayweed, cleats, clot, colt-herb, coltsfoot, coughwort, coutfit, cow-heave, dishalaga, dove-dock, dummy weed, floatweed, foalfoot, foilefoot, hog-weed, hoofs, horse-hoof, horse-hove, son-before-the-father, sow foot, tushalan, tushylucky gowan.

Urtica dioica, *L.*—Naughty man's plaything, nettle, scaddie, stinging nettle, stingy nettle, tenging nettle.

Urtica urens, *L.*—Burning nettle, dog nettle (?), ettle, small nettle, stingy nettle.

Valerianella olitoria, *Mœnch.*—Cornel-sallet, corn salad, lamb's lettuce, milk grass, potherb, white potherb.

Veronica agrestis, *L.*—Chickweed, field speedwell, garden speedwell, germander, germander chickweed, germander speedwell, winter-weed.

Veronica arvensis, *L.*—Corn speedwell, wall speedwell.

Veronica chamædrys, *L.*—Angel's-eyes, astrophell, base vervain, billy bright-eye, bird's-eye, blue bird's-eye, blue eye, blewart, blind flower, blue stars, bobby's eyes, bonny-birdee, cat's-een, cat's-eyes, deil's flower, English treacle, eyebright, flat vervain, forget-me-not, germander, germander speedwell, god's eye, lady's thimble, love-me-not, milkmaid's eye, poor man's tea, remember me, speedwell, wild germander, wish me well.

Veronica hederæfolia, *L.*—Bird's eye, botherum, corn speedwell, dotherum, hen-bit, ivy chickweed, ivy-leaved speedwell, morgeline, mother of wheat, winter-weed.

Veronica serpyllifolia, *L.*—Paul's betony, thyme-leaved speedwell.

Veronica tournefortii, *Gmel.*—Bird's-eye, cat's-eyes, cuckoo's leader, large field speedwell.

Vicia angustifolia, *L.*—Narrow-leaved vetch.

Vicia cracca, *L.*—Blue tar-fitch, cat-peas, cow vetch, huggaback, mice pea, tar grass, tine, tine grass, tufted vetch, twine grass, wild fetches, wild tare, wild thetch grass, wild vetch or fitch.

Vicia hirsuta, *L.*—Bindweed, dill, dother, fitch, hairy tare, lintels, strangle-tare, tare, tar-fitch, tar grass, tar vetch, tine grass, tine tare, tine-weed, titters, wild thetch grass.

Vicia sativa, *L.*—Chichelings, cichlings, fatch, fetch, fitch, fitchacks, gore-thetch, lints, pebble-vetch, racers, tar, tare, tere, thatch, thetch, twadgers, urles, vatch, vetch, wild fitch.

Vicia sepium, *L.*—Crow-peas, dill, hedge vetch, tare, thatch, thetch, twadgers, vetch, wild tare, wild vetch.

Vicia tetrasperma, *Mœnch.*—Smooth tare.

Viola tricolor, *L.*—Beedy's eyes, Biddy's eyes, bleeding heart, buttery-entry, call-me-to-you, cat's-faces, cull-me-to-you, face-and-hood, fancy, flamy, garden gate, godfathers and godmothers, heartsease, heart's pansy, heart seed, herb trinity, jack-behind-the-garden-gate, jump-up-and-kiss-me, kiss-me, kiss-me-over-the-garden-gate, Kitty-run-the-streets, leap-up-and-kiss-me, live-in-idleness, look-up-and-kiss-me, love-in-idle, love-in-idleness, love true, meet-her-i'-th'-entry-kiss-her-i'-th'-buttery, monkey's face, pance, pansy, paunce, pensy, pink-o'-my-John, stepmother, three faces in a hood, tickle-my-fancy, tittle my fancy, two-faces-under-the-sun, violet, violet (horse, trinity), wild love and idle.

AUTHOR INDEX.

Adam, J. (1789), 51, 53, 112, 115.
A. D. H. (1900), 70.
Amos, A. (1917), 50.
Anderson, J. (1779), 49, 53.
Andrews, G. H. (1853), 191, 202.
Anzibor, S. (1912), 46.
Armstrong, S. F. (1907), 176.

Barthe, L. (1918), 106, 111.
Bernatsky, J. (1915), 193.
Berry, R. A., Robinson, G. W., and Russell, E. J. (1918), 199.
Blith, W. (1652), 46.
Borneman (1913), 108.
Brenchley, W. E. (1911), 121.
— — (1912), 121.
— — (1913), *a*, 121.
— — (1913), *b*, 99.
— — (1915), 121.
— — (1916-17), 107, 112, 121, 183, 189.
— — (1918), 79, 140.
— — (1919), *a*, 6.
— — (1919), *b*, 203.
Britten, J., and Holland, R. (1886), 206.
Buckman (1855), 139, 145, 152.

Carruthers, W. (1906), 66.
Clark, G. H., and Fletcher, J. (1909), 4, 12.
Cockayne, A. H. (1915), 70.
Collinge, W. E. (1913), 28, 75.
— — (1914), 28.
Cox, H. R. (1915), 68.
— — (1918), 114.
Crichton Browne, J. (1917), 193.
Culpepper, 189.
Cushny, A. R. (1918), 192.

Degen, A. (1916), 105.
Dorph Petersen (1910), 74.
Dusserre, C. (1916), 60.

Eversheд, A. F. C. H. (1918), 29.
Ewart, A. J. (1909), 103, 104, 106, 110, 115.

Farcy, J. (1910), 96.
Fau, E. (1910), 202.
Fleming, C. E. (1918), 111.
Flückiger and Hanbury (1874), 192.
F. M. (1910), 115.

Garcia Santos (1916), 204.
Garman, H. (1903), 97.
Gerarde (1863), 187, 190, 192.
Gordon, G. P. (1916), 65.
Gümbel, H. (1912), 83.

Hall, A. D., and Russell, E. J. (1911), 175.
Hanasek, T. Z. (1915), 191.
Hansen, K. (1911), 74.
Hansen und Mez (1916), 198.
Hardie, W. (1904), 49.
Henderson, T. B. R. (1909), 115.
Hendrick (1918), 204.
Henslow, G. (1901), 104, 105, 111, 112.
Hill, A. W. (1917), 76.
Hiltner (1911), 57.
Hogg, R., and Johnson, G. W. (1863), 187-203.
Houghton (1728), 201.
Howitt, J. E. (1916), 107, 110.
Hunter, A. (1803), 64.
Hutchison, H. P. (1912), 69.

D'Ippolito, G. (1913), 95.

Jaguenaud, G. (1912), 59.
Johnson, C. P. (1861-2), 190, 193, 194, 201, 203.

Kellerman, W. A. (1895), 110.
Kerner, A., and Oliver, F. W. (1895), 75.
Kling, M. (1915 ?), 191, 193, 201.
Knapp, F. H. (1846), 187, 191, 193, 194, 197, 198, 201.

Lindley, J., and Moore, T. (1889), 188, 190, 194-202.
Long, H. C. (1912), 50.
— — (1910), 47, 139, 152.
— — (1917), 104, 105, 106, 107, 115.

Maiden, J. H. (1916), 111.
Martin, J. B. (1916), 57.

McGeorge, W. T. (1915), 59.
Milburn, T. (1916), 65.
Milne, D. (1915), 75.
Montemartini, L. (1913), 94.
Morettini, A. (1915), 59.
— — (1914), 75.
Munerati, O., and Zapparoli, T. V. (1913), 78.

Nelson, J. C. (1917), 12.

Parkin, J. (1918), 79.
Parkinson, J. (1629), 187.
Passerini, N. (1910), 79.
Patterson, H. J., and White, H. J. (1912), 74.
Pliny (Holland's Translation, 1864), 187, 188, 200.
Pratt, A. (n.d.), 187, 191, 193-202, 205.
Prior, R. C. A. (1879), 207.

Rabaté, E. (1911), 58.
Rendle, A. B. (1915), 11.
— — (1913), 51.

Smith, J. D. (1917), 111.
Stapledon, R. G. (1910), 178.
— — (1916), 11.
Stebler and Schroeter (1908), 108.
Stephenson, J., and Churchill, J. M. (1834), 194, 202.
Strickland, H. E., Daubeny, Henslow, and Lindley (1850, 1857), 72.

Theophrastus (322 B.C.), 192.

Underwood, L. M. (1912), 42.

Voelker, J. A. (1911), 53, 191.
— — (1918), 54.

Waldron, L. R. (1904), 78.
Wilson (1847), 186, 189-202, 205.
Woodruffe Peacock, E. A. (1917), *a*, 17.
— — — (1917), *b*, 28.
— — — (1918), 16.
Woodville, W. (1790-1792), 188, 191, 194, 195, 199, 202.

GENERAL INDEX.

Achillea millefolium. See Yarrow.
Acid soil, 118, 119, 120, 141, 151.
Adventitious roots, 88.
Æthusa cynapium, 73, 106, 128, 206.
Agrimonia eupatoria, 26 (fig.), 188, 189, 206.
Agrimony, 25, 26 (fig.), 116, 188, 189, 206.
Agropyron repens. See Couch-grass.
Agrostis. See Bent-grass.
A. alba, 190, 206.
A. stolonifera, 38, 151, 206.
A. vulgaris, 206.
Aira cæspitosa, 112, 178, 206.
A. caryophyllea, 206.
Ajuga reptans, 207.
Alchemilla arvensis. See Lady's Mantle.
A. vulgaris, 178, 207.
Alfalfa, 59, 96. See also Lucerne.
Allium ursinum. See Ramsons.
A. vineale. See Crow Garlic and Wild Onion.
Alluvial areas, 177.
Alopecurus agrestis, 154. See also Black Bent.
A. geniculatus, 207.
A. pratensis, 27, 75.
America, 97, 115.
American Weeder, 47.
Ammonium sulphate, 69.
Anagallis arvensis. See Scarlet Pimpernel.
Animals, weeds distributed by, 23, 74, 75.
Annual weeds, 46, 58, 84.
Anthemis arvensis. See Corn Chamomile.
A. cotula, 134, 156, 207.
Anthoxanthum odoratum, 182.
Anthriscus sylvestris. See Wild Chervil.
Anthyllis vulneraria, 187, 208.
Antirrhinum orontium, 208.
Arabis thaliana, 129, 208.
Arable land, eradication of weeds from, 46-63.
— weeds, definition of, 2.
— — in grass fields, 16.
Arctium lappa, 73.
Arenaria serpyllifolia. See Sandwort.
Arnoseris pusilla, 208.
Arrhenatherum avenaceum, 27, 208.
A. avenaceum var. *tuberosum*, 39, 41 (fig.).
Arrowhead, 178.
Arsenite of soda, 59, 67, 96.
Artemesia vulgaris, 208.
Asparagus, Bath, 91, 196. See also *Ornithogalum pyrenaicum*.
Assimilation of carbon-dioxide, 5.
Association of weeds with all crops, 162-4.
— — — — cereals, 172-4.
— — — — peas and beans, 162, 170, 171.
— — — — root crops, 162, 164.
— — — — "seeds," 162, 166-8.
Aster tripolium, 118.
Atriplex patula. See Orache.
Australia, 4, 11, 43, 59, 110.
Avena fatua. See Wild Oat.
A. flavescens, 27.
A. strigosa, 12.
Avens, 26, 194.
Awn, hygroscopic, 25, 188.

Ballast, weeds distributed by, 10, 12.
Barberry, 70.
Barley, 5, 6, 7, 51, 57, 59, 99, 101 (fig.), 115, 161-74.
— meadow, 178.
— wall, 27.
— wild, 112.
Barn field, Rothamsted, 9.
Bartsia odontites. See Red Bartsia.
Bartsia, red, 91, 93, 102 (fig.), 148, 149, 150, 156, 165, 174.
Basic slag, 69, 99.
Bastard-alkanet, 195.
Battlefield, Somme, 76.
Beans, 58, 161-74.
Bedstraw, 94.
— ladies'. See *Galium verum*.
— marsh, 178.
Belgium, 112.
Bellis perennis. See Daisy.

Bent, black, 7, 8 (fig.), 52, 120, 134, 135, 153, 156, 170, 171, 174, 207. See also *Alopecurus agrestis* and Slender Foxtail.
Bent-grass, 38, 88, 126, 127, 151, 156, 169, 174, 176, 179, 190, 206.
Biennial weeds, 58, 85, 110.
Bilberry, 195.
Bindweed, 11, 29 (fig.), 31, 36, 70, 71, 75, 89, 104, 136, 137, 153, 156, 162, 163, 176, 178, 193, 212.
— black, 11, 31, 62, 89, 111, 123, 126, 127, 151, 152, 157, 169, 170, 173, 197, 220.
— greater, 73.
Birds, weeds distributed by, 28.
Bisulphate of sodium, 60.
Bittersweet, 31, 223.
Blue bur, 11.
Boggy soil, 117.
Bone meal, 69.
Borage, 190, 208.
Borago officinalis, 190, 208.
Botanical analysis, 176.
Brachypodium pinnatum, 63, 69, 178, 179.
B. sylvaticum, 63, 69, 178, 179.
Bracken, 64, 65, 67, 104, 181, 198.
Brassica, 11, 20, 75, 82.
B. alba, 139, 146, 147, 156, 165, 209.
B. campestris, 56, 128, 209.
B. sinapis, 56, 76, 136, 139, 147, 151, 156, 162, 163, 173, 209.
Bread, 191, 198, 199, 201.
British Association, 11.
Briza media, 179, 180 (fig.), 209.
Broadbalk field, Rothamsted, 7, 9, 52, 138, 140.
Brome, 112.
— false, 63, 69, 178, 179.
— field, 182, 185, 209.
— rough, 178.
— soft, 44, 178, 179.
— sterile, 27. See also *Bromus sterilis*.
Bromus arvensis, 185, 209. See also Field Brome.
B. asper, 209. See also Rough Brome.
B. mollis, 44, 178, 179, 209.
B. secalinus, 209.
B. sterilis, 27, 186, 209.
Broom, 64.
Broomrape, 20, 70, 79, 91, 93, 96 (fig.), 98, 99, 104, 111, 218.
— branched, 97.
— eradication, 98.
— lesser. See *Orobanche minor*.
Bryonia dioica, 73.
Bryony, white, 73.
Bugloss, small, 150, 157, 216.
Bulb, 38, 86, 90.
Bulbils, 39, 53.
Bullocks, 75.
Burdock, 73.
Burial, means of seed, 77.
Buried seeds, 64, 76, 78-83, 95, 97, 140.
Burnet, salad, 54, 178, 181, 198, 220.
Buttercup, 3, 4, 16, 26, 31, 66, 104, 105, 115, 178, 221.
— bulbous, 37 (fig.), 38, 87, 129, 177, 185.
— corn, 25, 26 (fig.), 27 (fig.), 57, 58, 87, 116, 120, 134, 135, 153, 158, 170, 174, 221.
— creeping, 18, 28, 38, 40 (fig.), 88, 126, 128, 151, 158, 165, 176, 187.
— tall, 148, 149, 150, 158, 177, 185, 199.

Cabbage, field, 128.
Calamintha acinos, 209.
Calcifuge, 127.
Calcium carbonate, 118, 119.
— cyanamide, 60, 61.
Calves, 105.
Camelina sativa, 191, 210.
Campanula corn, 150, 157, 215.
Campion, bladder, 70, 73, 148, 158, 171, 174, 201, 223.
— red, 128, 216.
— white, 147, 148, 149, 153, 157, 159, 165, 167, 216.
Canada, 4, 11, 12, 43, 107, 116, 189.
Capsella bursa-pastoris. See Shepherd's Purse.
Caraway, 73.
Carbolineum, 62.
Cardamine pratensis, 210. See Lady's Smock.
Carduus nutans, 23, 150, 156, 167, 179, 210.
Carex, 179, 190, 210.
C. glauca, 210.
C. hirta, 210.
C. vulpina, 210.
Cargoes, weeds distributed by, 10, 11, 12.
Carr land, 151.
Carrot, wild, 25, 26 (fig.), 44, 58, 73, 86, 147, 148, 156, 167, 179, 212.
Cart tracks, weed flora of, 16, 183.
Carum carvi, 73.
Catmint, 73.
Cat's ear, 104, 151, 179, 186, 215.
Cat's tail, 16. See also *Phleum pratense*.
Cattle (and cows), 74, 75, 104, 107, 108, 110, 111, 186, 187-205.
Caucalis, knotted, 128.
Caucalis nodosa, 128, 210.

Centaurea nigra, 149. See also Hardhead.
C. scabiosa. See Greater Knapweed.
Cerastium vulgatum. See Mouse-ear Chickweed.
Cereal crops, 54, 62, 99, 159-74.
Chalk, intolerance of, 132, 133.
— land, weeds of, 124, 146.
— manuring, 51.
— soil, 117, 122, 127.
Chamomile, 16, 74, 76, 87, 115, 131, 132, 157, 217.
— corn, 62, 129, 130, 151, 156, 167, 207.
Characteristic weeds, 123, 134, 135, 141, 146, 153.
Charlock, 4, 11, 16, 17, 20, 28, 56, 57, 58, 59, 60, 61, 62, 70, 76, 81, 82, 83, 85, 87, 95, 104, 115, 136, 139, 146, 147, 151, 156, 160, 162, 163, 173. See *Brassica spp.*
Chemical means, eradication by, 45, 54-63, 66-70.
Chenopodium album. See Fat Hen.
Chervil, wild, 17, 46, 64, 176, 179, 185, 207.
Chickweed, 4, 9, 18, 19, 28, 31, 46, 62, 85, 87, 112, 123, 126, 127, 151, 158, 169, 183, 201, 224.
— mouse-ear, 16, 17, 19, 28, 87, 126, 128, 156, 165, 168, 174, 181, 183, 211.
Chicory, 54, 117, 191, 211.
Chloride of lime, 62.
Chrysanthemum leucanthemum. See Dog Daisy.
C. segetum. See Corn Marigold.
Cichorium intybus. See Chicory.
Cicuta virosa. See Cowbane.
Cicutin, 111.
Cinquefoil, creeping, 38, 129, 198, 220.
Circæa lutetiana, 27.
Cirsium acaule, 65, 211.
C. arvense, 36, 179. See also Creeping Thistle.
C. lanceolatum, 23, 179. See also Spear Thistle.
C. palustre. See Marsh Thistle.
Classification of soils, 122.
Clay, 117, 120, 122, 127, 129.
Cleaning crops, 49, 161.
Cleavers, 52, 85, 116, 153, 157. See also Goosegrass.
Climbing weeds, 89.
Clover, 6, 50, 51, 53, 5 4, 55, 67, 75, 91 93, 95, 96, 98, 111, 159, 166.
— suckling, 44.
— sweet, 11, 104. See also *Melilotus*.
Cocksfoot, 26, 182, 185, 186.
Coffee substitutes, 189, 191, 193, 202.
Colchicine, 108.
Colchicum autumnale, 38, 91, 107, 109 (fig.), 178, 192, 212. See also Autumn Crocus and Meadow Saffron.
Colonisation of dumps by weeds, 12.
Coltsfoot, 18, 23, 24 (fig.), 34 (fig.), 37, 53, 89, 120, 136, 137, 138, 158, 165, 166, 202, 225.
Competition, aerial, 6, 50, 159.
— between plants, 5, 68, 117, 118, 119, 120, 127, 132, 159, 160, 166, 174, 181.
— root, 6.
Compost heap, 48.
Coniine, 106, 192.
Conium maculatum. See Hemlock.
Conopodium denudatum. See Pignut.
Continuous cropping, effect of, 7, 9.
Convolvulus, 75.
C. arvensis. See Bindweed.
C. major, 73.
Copper sulphate, 55, 56, 57, 59, 67.
Corm, 38.
Corn cockle, 4, 11, 104, 105, 106, 126, 157, 186, 216.
— gromwell, 146, 147, 157, 195, 216.
— salad, narrow fruited, 73.
Cornflower, 58, 62.
Cosmopolitan weeds, 4, 128.
Cotton-grass, 177.
Couch grass, 16, 17, 32 (fig.), 36, 48, 50, 53, 88, 120, 127, 136, 138, 156, 169, 174, 176, 179, 189, 206.
— onion, 39, 41 (fig.), 90, 208.
Cowbane, 104, 110. See also Water Hemlock.
Cowslip, 181, 220.
Cow-wheat, 93, 112.
Crane's-bill, 20, 214. See also Geranium.
— small-flowered, 150, 157, 167.
— soft or dove's foot, 129, 130, 157, 167, 172, 173, 174, 183, 214.
Creeping jenny, 178, 217.
— weeds, 88.
Crepis, 23.
C. taraxacifolia, 178, 212.
C. virens, 97, 212.
Crocus, autumn, 104. See also *Colchicum autumnale*.
Cudweed, 23, 150, 156, 167, 213.
— marsh, 141, 146, 157, 214.
Cultivation, weeds of, 10.
Cumarin, 115.
Cuscuta. See Dodder.
C. arvensis, 95.
C. epilinum, 94.
C. epithymum, 94.
C. europæa, 94, 212.
C. gronovii, 95.

C. trifolii, 93 (fig.), 94, 95, 212.
Cutting, eradication of weeds by, 64, 65.

Dactylis glomerata. See Cocksfoot.
Daffodil, 181.
Daisy, 16, 28, 88, 128, 178, 181, 183, 208.
— dog or ox-eye, 63, 68, 115, 128, 178, 179, 186, 211.
Dandelion, 16, 23, 24 (fig.), 26, 28, 67, 88, 148, 149, 151, 158, 171, 179, 185, 201, 224.
Darnel, 11, 104, 112, 114, 115, 216.
Daucus carota, 97. See also Wild Carrot.
Dead-nettle, red, 87, 131, 132, 157, 169, 215.
— white, 188.
Destruction of weed seedlings, 3.
Digitalis purpurea, 97.
Discouragement of weeds by peas and beans, 162, 171, 172.
— — — — root crops, 162, 165, 166.
— — — — "seeds," 162, 168.
Diseases, fungus, 70.
Distributed weeds, 122.
Distribution of weeds, 10, 152.
Dock, 4, 21, 26, 28, 43, 44, 45, 46, 48, 69, 88, 95, 176, 177, 179. See also *Rumex spp*.
— blood-red. See *Rumex sanguineus*.
— broad-leaved, 16, 22 (fig.), 73, 131, 133, 158, 177, 183, 185, 200. See also *Rumex obtusifolius*.
— curled, 47, 123, 126, 127, 151, 158, 162, 163, 164, 222. See also *Rumex crispus*.
— sharp, 177, 185. See also *Rumex conglomeratus*.
Dodder, 4, 20, 59, 75, 91, 93 (fig.), 94, 95, 96, 99, 104, 179.
— clover, 93, 94, 95, 96.
— eradication of, 95.
— flax, 93.
— lesser, 94.
Dog's mercury, 95.
Dog's-tail, 182.
Dominant weeds, 122.
Dominions, 43, 111, 115.
Drainage, 107, 177, 181.
Dry storage of seeds, 73.
Duration of weeds, 84.
"Dutch Pink," 188.
"— rushes," 193.
Dyer's Rocket, 188.
— weed, 112.
Dyes, 188, 189, 194, 195, 197, 199, 204.

Echium vulgare, 212. See also Viper's Bugloss.
Elliott's mixture, 53, 54, 191.
Epilobium, 23, 25 (fig.).
E. angustifolium, 76. See also Fireweed.
E. hirsutum, 212.
Equisetum, 106, 107, 178, 213. See also Horsetail.
E. arvense, 107. See also Horsetail.
E. hyemale, 193.
E. palustre, 66, 107.
Eradication of weeds, 45, 71.
Erect weeds, 86.
Erigeron canadense, 213.
Erodium cicutarium, 213.
E. spp, 20, 213.
Erysimum cheiranthoides, 213.
Euphorbia. See Spurge.
E. exigua, 152. See also Dwarf Spurge.
E. helioscopia. See Sun Spurge.
E. peplus. See Petty Spurge.
Euphrasia, 93.
E. officinalis. See Eyebright.
Eyebright, 93, 179, 213.

Fairy rings, 181, 182.
Fallowing, 52, 102.
Farm implements, weeds distributed by, 15, 45.
Fat hen, 12, 13 (fig.), 16, 31, 48, 74, 75, 85, 87, 123, 126, 127, 140, 151, 152, 156, 169, 173, 174, 183, 190, 211.
"Fatting" pasture, 176.
Feeding value, 175, 176, 177, 179.
Fen land, 151.
Fescue, tall, 27.
Festuca elatior, 27.
Fibre, 190, 203, 204.
Filago germanica. See Cudweed.
Fireweed, 76, 83.
Flax, 94.
— purging, 104, 108, 109 (fig.), 176, 178, 216.
Flour substitutes, 189, 191, 201.
Fodder, 189, 190, 191, 193, 198, 201, 202, 204.
Fool's parsley, 17.
Forget-me-not, 17, 27, 122, 126, 128, 157, 168, 174, 217.
Foxtail, 27, 75, 185, 186.
— slender, 16. See also *Alopecurus agrestis*.
France, 51, 60, 115.
Frequency of occurrence, 122, 124.
— percentage of, 125, 161.
Fritillaria meleagris, 181.
Fritillary, 181.

Fruits and seeds, weeds distributed by, 18.
Fumaria officinalis. See Fumitory.
Fumitory, 62, 85, 147, 148, 149, 156, 171, 193, 213.
Fungi, 181, 182.
Fungus diseases, 70.

Galeopsis tetrahit, 151, 213.
Galium aparine, 213. See also Goosegrass and Cleavers.
G. tricorne, 214.
G. verum, 181, 188, 194, 214.
Garlic, 3, 112, 113 (fig.), 114, 115, 176, 178, 207. See also Wild Onion.
Gas lime, 69.
Geese, 105, 187-205.
General occurrence, weeds of, 123, 124.
Genista tinctoria. See Woodwax.
Geranium, 20, 214. See also Crane's-bill.
Geranium, 21, 87, 159. See also Crane's-bill.
— cut-leaved, 134, 153, 157, 167.
Geranium dissectum, 214. See also Cut-leaved Geranium.
G. molle, 11. See also Soft Crane's-bill.
G. pratense, 214.
G. pusillum, 150, 157, 167, 214.
G. robertianum, 11.
G. sylvaticum, 65.
Geranium, wood, 65.
Germany, 68, 107.
Germination of weed seeds, 3, 7, 14, 47, 72, 74, 83, 94, 97.
Geum, 116.
G. urbanum, 26, 194.
Githagin, 105.
Glaux maritima, 118.
Gnaphalium uliginosum, 23. See Marsh Cudweed.
Goats, 106, 108, 187-205.
Goatsbeard, 23, 24 (fig.), 181, 224.
Gold-of-pleasure, 190, 210.
Goosegrass, 25, 26 (fig.), 27, 28, 31, 90, 136, 138, 169, 174, 193, 214. See also Cleavers.
Gorse, 4, 71, 73, 78, 93, 202.
Grass-land weeds, definition of, 2, 176.
— — eradication of, 63-70.
Grazing, eradication of weeds by, 63, 64.
— with cattle, 63, 64.
— — geese, 64.
— — sheep, 63, 64, 102, 110.
Ground ivy, 104, 129, 195, 217.
Groundsel, 9, 16, 23, 24 (fig.), 28, 62, 85, 87, 126, 127, 151, 158, 162, 163, 164, 183, 200, 223.

Habits of growth of weeds, 86.
Hardhead, 23, 63, 146, 147, 156, 171, 178, 179, 210.
Hawaii, 59.
Hawkbit, 16, 23, 24 (fig.), 70. See also *Leontodon spp.*
— autumnal, 17, 215.
Hawk's-beard, 23
— beaked, 178, 212.
Hawkweed, mouse-ear, 23, 38, 39 (fig.), 176, 181, 215.
Heath, 78, 94.
Heating in stack, 90.
Heavy land, weeds of, 123, 134.
Hemlock, 4, 46, 73, 86, 104, 106, 176, 187, 192, 212.
— water, 104, 110, 111.
Hemp, 97.
Henbit, 150, 157, 215.
Heracleum sphondylium. See Hogweed.
Hieracium pilosella. See Mouse-ear Hawkweed.
Hippocrepis comosa, 17.
Hogweed, 21, 22 (fig.), 27, 112, 147, 148, 149, 157, 179, 182, 194, 214.
Holcus lanatus. See Yorkshire Fog.
Holland, 190.
Hooked fruits, 25, 115.
Hoos field, Rothamsted, 7.
Hordeum murinum, 27.
H. pratense, 178, 215.
Horses, 74, 75, 104, 105, 107, 108, 110, 111, 186, 187, 204.
Horsetail, 31 (fig.), 36, 89, 104, 106, 136, 140, 151, 153, 156, 169, 193, 213. See also *Equisetum spp.*
— field, 106, 107, 178. See also *Equisetum spp.*
— marsh, 66, 107.
Huffcaps, 112, 178, 205.
Human beings, weeds distributed by, 23, 26.
Hygroscopic awn, 25, 188.
Hypericum hirsutum, 73.
Hypochæris radicata, 97. See also Cat's Ear.

Impure seed, transport, 10.
India, 75.
Insect pests, 70, 71.
Ireland, 43.
Iron sulphate, 55, 57, 58, 59, 61, 67, 96.
Isatis tinctoria, 194.
Isle of Man, 43.
Italy, 70.
Ivraie, 115.

Juncus. See Rush.
J. articulatus, 215.

J. bufonius. See Toad Rush.
J. communis, 215.
J. glaucus, 215.

Kainit, 60, 61, 62, 68.
" Kendal green," 194.
Knapweed, greater, 23, 147, 148, 156, 211.
Knawel, annual, 87, 120, 141, 142, 143 (fig.), 158, 200, 223.
Knotgrass, 16, 19 (fig.), 28, 31, 48, 53, 81, 87, 95, 124, 126, 127, 151, 157, 163, 170, 183, 197, 219.

Lady's mantle, 87, 131, 132, 153, 156, 168, 172, 174, 178, 207.
— smock, 178, 210.
Lamium amplexicaule, 150, 157, 215.
L. purpureum. See Red Dead-nettle.
Lappula echinata, 11.
Lapsana communis. See Nipplewort.
Lathyrus macrorrhizus, 215.
L. pratensis, 215.
Lawns, 67, 182.
Laying down to grass, 52, 53.
Legislation, weed, 43, 44, 94.
Legousia hybrida, 150, 157, 215.
Leontodon. See Hawkbit.
L. autumnalis, 17, 215.
L. hispidus, 215. See also Hawkbit.
Lettuce, lamb's, 146, 147, 158, 225.
— wild, 95.
Ley, 87, 166.
Light land, weeds of, 124, 141.
Lime, 61, 62, 68, 69, 98, 118, 119, 141.
— nitrogen, 60, 61.
— requirement, 119.
— soils deficient in, 62, 69, 118, 145.
Linaria elatine, 215.
L. minor, 215.
L. spuria, 215. See also Round-leaved Toadflax.
L. vulgaris. See Toadflax.
Linum catharticum. See Purging Flax.
Lithospernum arvense. See Corn Gromwell.
Loam, 117, 122.
— heavy, 122, 129.
— light, 122.
Lodging of cerea's, 89.
Lolium temulentum. See Darnel.
Longevity of seeds, 73.
Loosestrife, purple, 178.
Lotus corniculatus, 17, 97.
Lousewort, 179.
Lucerne, 50, 95, 96, 98. See also Alfalfa.
Lupin, 58.
Luzula campestris, 216.
Lychnis alba = *L. vespertina*, 216.
L. dioica, 128, 216.
L. flos-cuculi. See Ragged Robin.
L. githago. See Corn Cockle.
L. vespertina. See White Campion.
Lycopsis arvensis, 150, 157, 216.
Lysimachia nummularia. See Creeping Jenny.

Madder, field, 126, 128, 158, 159, 167, 174, 223.
Manure heap, weeds of, 48, 183.
— weed seeds in, 75.
— weeds distributed by, 12, 49, 75.
Manures and Manuring, 9, 48, 54, 55, 60, 62, 66, 68, 98, 182, 189, 191, 193, 198, 201, 203.
Marigold, corn, 51, 87, 117, 141, 145 (fig.), 156, 211.
— marsh, 178.
Marsh plants, 178.
Matricaria chamomilla. See Chamomile.
M. inodora. See Mayweeds.
Mayweed, 16, 31, 62, 74, 87, 95, 104, 115, 132, 183, 187.
— scentless, 131, 132, 151, 157, 165, 174, 217.
— stinking, 134, 156.
Meadow-grass, annual, 87, 131, 132, 151, 157, 169, 170, 174, 183, 219.
— rough-stalked, 182, 183, 184 (fig.), 185.
— smooth-stalked, 185.
Meadowsweet, 177, 224.
Mechanical means, eradication of weeds by, 45, 46-54, 63-6.
Medicago, 11, 58. See also Medick.
M. lupulina, 74, 97, 217.
M. sativa, 97.
Medicinal uses of weeds, 187, 188, 189, 191, 192, 193, 194, 195, 196, 200, 201, 202.
Medick, 58, 166. See also *Medicago.*
— black. See *Medicago lupulina.*
Melampyrum, 93, 112.
Melilot, 112, 115.
Melilotus, 112, 115.
M. officinalis, 217.
Mentha aquatica, 217.
M. arvensis. See Corn Mint.
Mercurialis perennis, 95.
Mignonette, wild, 124, 146, 147, 158, 167, 188, 221.
Migration of weeds, 43.
Milk, tainting of, 112, 113, 114, 115.
Milkwort, 178, 219.
Mint, 178.
— corn, 88, 136, 140, 157, 169, 217.
Mixen-weed, 48.
Moisture, weeds distributed by, 15, 16.

Morning glory, 75.
Moss, 69, 70.
Mosses, 181.
Muck-weed, 48.
Mud, weeds distributed by, 15, 16.
Mullein, great, 73.
Mustard, 50, 75, 115.
— ball, 11.
— hedge, 129, 223.
— mithridate, 17, 224. See also *Thlaspi arvense.*
— white, 123, 139, 146, 147, 156, 165.
Mycelium, 182.
Myosotis arvensis. See Forget-me-not.
M. palustris, 217.
M. versicolor, 217.
Myosurus minimus, 217.

Narcissus pseudo-narcissus, 181.
Nepeta cataria, 73.
N. glechoma, 129, 195, 217.
Neslia paniculata, 11.
Nettle, hemp, 151, 213.
— small, 141, 143, 153, 158, 225.
— stinging, 46, 62, 64, 65, 66, 68, 88, 94, 95, 129, 176, 179, 185, 186, 188, 194, 203, 225.
New Zealand, 11, 70, 110.
Nickel sulphate, 59, 60.
Nightshade, black, 31, 95, 111, 224.
— enchanter's 26.
Nipplewort, 87, 136, 140, 157, 215.

Oat, tall, 27, 42, 176.
— wild, 4, 12, 15, 16 (fig.), 25, 51, 58, 71, 188, 208.
— yellow, 27.
Oats, 11, 50, 57, 59, 61, 78, 100, 112, 161-74.
Occasional weeds, 122.
Œnanthe crocata, 73.
Œ. pimpinelloides, 217.
Oil, 190.
Onion, wild, 17, 18, 38, 39, 53, 58, 91. See also Garlic.
Ononis repens = O. arvensis, 18, 179, 217.
Orache, 12, 14 (fig.), 62, 81, 87, 136, 140, 151, 156, 169, 183, 188, 208.
Orchard grass, 186. See also Cocksfoot.
Orchis, early. See *Orchis mascula.*
Orchis maculata, 218.
O. mascula, 195, 196, 218.
O. morio, 218.
Ornithogalum pyrenaicum, 38, 91, 196, 218.
Ornithopus perpusillus, 218.
Orobanche. See Broomrape.
O. major, 218.
O. minor, 96, 97, 111.
O. ramosa, 97.
Overcrowding, effect of, 5, 6.

"Panaisie," 112.
Pansy, field, 31, 87, 147, 148, 149, 151 152, 158, 165, 167, 226.
Papaver argemone, 131, 133, 157, 218.
P. dubium, 128, 218.
P. hybridum, 219.
P. rhœas. See Poppy.
Paper-making, 189.
Pappus, 23.
Parasites, eradicat on of weeds by, 70.
Parasitic weeds, 91, 92-102, 179.
Parsley, fool's, 73, 104, 106, 128, 205.
Pasture, calcareous, 64.
— down, 63, 69.
— old, 2, 76, 77, 79.
Pea, wild, 71.
Peas, 48, 58, 161-74.
Peat, 122, 144, 177.
— soils, weeds of, 124, 150.
Pedicularis, 93.
P. palustris, 179.
P. sylvatica, 219.
Pennycress, 115. See also *Thlaspi arvense.*
Pennywort, 178.
Perennial weeds, 46, 86, 88.
Persecaria, 17, 31, 62, 104. See also Willow-weed.
Pests, insect, 70, 71.
Pheasant crops, weed seeds in, 29.
Phleum pratense, 75. See also Cat's-tail.
Physiological conditions in soil, 83.
Pig, 74, 105, 108, 187-205.
Pignut, 38, 87, 178, 181, 185, 186, 192, 193, 212.
Pigweed, 75.
Pimpernel, scarlet, 16, 19, 31, 73, 85, 87, 104, 147, 148, 149, 156, 165, 173, 187, 207.
Pimpinella saxifraga, 219.
Plant nutrition, 92, 94, 99.
Plantago coronopus, 219.
P. lanceolata. See Ribwort Plantain.
P. major. See Greater Plantain.
P. media. See Hoary Plantain.
Plantain, 31, 74, 88.
— greater, 9, 16, 88, 136, 157, 165, 173, 181, 183, 184 (fig.), 197, 219.
— hoary, 73, 88, 94, 120, 134, 153, 157, 181, 183, 197, 219.
— ribwort, 28, 74, 88, 123, 126, 127, 157, 167, 172, 173, 181, 197, 219,
Ploughing, deep, 51.
— effect of, 46.
Plumed fruits, 23, 24 (fig.).
— seeds, 23, 25 (fig.).

Poa annua. See Annual Meadow-grass.
P. pratensis, 185.
P. trivialis. See Rough-stalked Meadow-grass.
Poisonous plants, 104-11, 176, 178.
Polygala vulgaris, 178, 219.
Polygonum aviculare. See Knotgrass.
P. convolvulus. See Black Bindweed.
P. lapathifolium, 220.
P. persecaria. See Willow-weed and Persecaria.
Poor-man's weather-glass, 149. See Scarlet Pimpernel.
Poppy, 5, 16, 20, 45, 56, 58, 61, 62, 70, 76, 81, 83, 85, 87, 104, 117, 128, 129, 130, 153, 154, 157, 160, 165, 173, 187, 196, 219.
— Destroyer, 47.
— pale, 131, 133, 157, 218.
— — red, 128. See also *Papaver dubium*.
" Poppyland," 154.
Pot cultures, 118.
Potash, 60, 199.
Potassium chloride, 60.
Potatoes, 58.
Potentilla anserina. See Silverweed.
P. reptans. See Creeping Cinquefoil.
P. tormentilla. See Tormentil.
Poterium sanguisorba, 97. See also Salad Burnet.
Poultry, 105, 187-205.
Prairie sunflower, 11.
Prevention of weeds, 43-5.
Primula veris, 181, 220.
Proclaimed plants (weeds), 4, 43.
Prostrate habit of grasses, 183, 185.
Prunella vulgaris, 129, 181, 220.
Prussic acid, 109.
Pteris aquilina. See Bracken.
Puffballs, 182.

Quaker Grass, 178, 179, 180 (fig.), 209.

Radish, wild, 48, 58, 60, 61, 62, 85, 87, 104, 126, 128, 158, 221.
Ragged Robin, 151, 177, 216.
Ragwort, 16, 65, 104, 109, 110, 178, 223.
— eradication of, 110.
Ramsons, 38, 112, 113 (fig.), 114, 178, 190, 207.
Ranunculus. See Buttercup.
R. acris, 26, 220. See also Tall Buttercup.
R. arvensis. See Corn Buttercup.
R. bulbosus, 26, 221. See also Bulbous Buttercup.
R. hirsutus, 221.
R. repens, 221. See also Creeping Buttercup.
Rape, 52.
Raphanus raphanistrum. See Wild Radish.
Rapistrum rugosum, 11.
Rattle, red, 93.
— yellow, 18, 21, 22 (fig.), 64, 91, 93, 98, 99, 100 (fig.), 101 (fig.), 102, 104, 178, 179, 199, 222.
Reproduction, sexual, 18.
— vegetative, 18, 31, 86.
Reseda, 112.
R. lutea. See Wild Mignonette.
R. luteola, 188.
Reserve food, 85, 87, 97.
Respiration, 5.
Restharrow, 18, 179, 217.
Rhinanthus crista-galli. See Yellow Rattle.
R. major, 99, 100 (fig.), 101 (fig.).
R. minor, 98.
Rhizomes, 88, 89, 110, 138, 189.
Ribgrass, 2, 4, 182. See also Ribwort Plantain.
Root crops, 6, 9, 49, 51, 58, 159, 161-74.
Rose-bay, 76.
Rosette weeds, 88, 176.
Rotation of crops, 6.
Rothamsted, 7, 42, 52, 59, 74, 79, 82, 118, 138, 139, 140, 152, 154.
Rumex acetosa, 144. See also Sorrel.
R. acetosella. See Sheep's Sorrel.
R. conglomeratus, 44, 222. See also Sharp Dock.
R. crispus, 44, 69, See also Curled Dock.
R. obtusifolius, 44, 69, 179, 183, 222. See also Broad-leaved Dock.
R. sanguineus, 26, 177, 222.
Running grasses, 49.
Rush, 66, 88, 177, 178, 179, 200, 215.
— toad, 20, 76, 183, 215.
Russia, 11, 107.
Rust, 70.
Ryegrass, 16, 53, 54, 182, 185, 186.

Saffron, meadow, 108, 176, 187. See also *Colchicum autumnale*, and Autumn Crocus.
Sainfoin, 55, 96.
St. John's wort, hairy, 73.
Salep, 196.
Salicornia spp., 118.
Salsify, purple, 73.
Salt, 67, 68, 99, 102, 118.
— marshes, 118.
Sandy land, 117, 120, 122, 141.

Sandwort, 31, 129, 130.
— thyme-leaved, 85, 156, 168, 174, 208.
Scabiosa arvensis. See Scabious.
S. succisa, 222.
Scabious, 124, 148, 158, 171, 179, 222.
Scale leaves, 32.
Scandix pecten. See Shepherd's Needle.
Scarce weeds, 122.
Scleranthus annuus. See Annual Knawel.
Scour, 107, 193.
Scrambling weeds, 89.
Sedge, 178, 179, 190, 210.
Seed production, abundant, 18, 77, 84.
— Testing Station, 44.
Seedlings, destruction of, 3.
"Seeds" crops, 6, 132, 161-74.
Selfheal, 129, 181, 220.
Senebiera coronopus. See Swine-cress.
Senecio jacobæa. See Ragwort.
S. vulgaris. See Groundsel.
Serradella, 55, 58.
Serratula tinctoria, 223.
Sexual reproduction, 18.
Sheep, 107, 108, 110, 111, 116, 186, 187-205.
Sheep's sorrel, 4, 18, 28, 36, 44, 49, 62, 68, 69, 74, 104, 111, 118, 119, 120, 141, 143, 144 (fig.), 151, 153, 154, 158, 162, 163, 174, 179, 223.
Shepherd's needle, 25, 28 (fig.), 50, 87, 126, 127, 153, 155, 158, 165, 173, 223.
— purse, 4, 16, 17, 20, 85, 88, 110, 112, 126, 127, 156, 162, 163, 164, 183, 210.
Sheradia arvensis. See Field Madder.
Silage crops, 50.
Silene anglica, 223.
S. inflata. See Bladder Campion.
S. noctiflora, 223.
Silverweed, 16, 38, 88, 104, 126, 128, 151, 158, 171, 179, 183, 184 (fig.), 197, 220.
Sisymbrium officinale, 129, 223.
Smother crops, 50, 51, 159, 166, 170.
Sodium arsenite, 59, 67, 96.
— bisulphate, 60.
— nitrate, 96.
Soils, classification, 122.
Solanum dulcamara, 31, 223.
S. nigrum, 31, 95, 111, 224.
Somme battlefield, 76.
Sonchus arvensis. See Corn Sowthistle.
S. oleraceus. See Sowthistle.
Sorrel, 21, 36 (fig.), 38, 68, 104, 118, 119, 178, 179, 182, 185, 186, 188, 199, 222. See also *Rumex acetosa*.
Sour land, 141.
Sowthistle, 23, 62, 70, 95, 201, 224.
— corn, 9, 18, 33 (fig.), 36, 48, 136, 151, 158, 162, 163, 164, 224.
Speedwell, 19, 31, 62, 87.
— field, 16, 17, 81, 82, 122, 126, 127, 139, 158, 162, 163, 164, 173, 225.
— germander, 181, 225.
— ivy-leaved, 82, 85, 131, 158, 169, 225.
— large field, 136, 139, 158, 169, 170, 225.
— thyme-leaved, 150, 158, 183, 225.
— wall, 131, 158, 168, 172, 174, 225.
Spergula arvensis, 154. See also Spurry.
Spiræa filipendula, 224.
S. ulmaria. See Meadowsweet.
"Splits," 125.
Spraying, time of, 56.
Sprays, 9, 54, 55, 59, 66, 67, 96.
Spurge, 20, 85, 87, 104, 111, 213.
— dwarf, 16, 136, 138, 156, 165, 213. See also *Euphorbia exigua*.
— petty, 126, 128, 156, 213.
— sun, 129, 130, 156, 171, 174, 187, 213.
Spurry, 4, 16, 19, 21, 22 (fig.), 31, 56, 62, 85, 87, 117, 120, 123, 141, 142 (fig.), 151, 153, 158, 160, 169, 170, 173, 174, 201, 224. See also *Spergula arvensis*.
Stachys arvensis, 111, 224.
S. betonica, 224.
S. palustris, 224.
Stagger weed, 111.
Star-of-Bethlehem, spiked, 38, 196. See also *Ornithogalum pyrenaicum*.
Stellaria graminea, 224.
S. media, 130, 191. See also Chickweed.
Stinkweed, 115. See also *Thlaspi arvense*.
Stitchwort, 187.
Stork's-bill, 20, 213.
Storm columns, weeds distributed by, 17.
Struggle for existence, 120.
Suæda fruticosa, 118.
S. maritima, 118.
Sub-dominant weeds, 122.
Sulphate, ammonium, 69.
— copper, 55, 56, 57, 59, 67.
— iron, 55, 57, 58, 59, 61, 67, 96.
— nickel, 59, 60.
Sulphuric acid, 55, 58, 60, 67.
Superphosphate, 69.
Survey, weed, 121.
Swine-cress, 16, 87, 136, 137, 158, 183, 223.

Switzerland, 108, 191.
Swollen internodes, weeds with, 90.
— stems, 38.
Symptomatic weeds, 120, 134.

TAINTING of milk, 112, 113, 114, 115.
Taraxacum vulgare. See Dandelion.
Tares, 50, 114.
Tarred paper, eradication of weeds by, 66.
Tasmania, weeds, 4.
Tea substitutes, 189, 194, 201.
Temporary grass, 162-74.
Tendril, 90.
"Testing of Seeds" Order, 44.
Thalecress, 129, 208.
Thatch, 190, 198.
Thistle, 18, 36, 43, 45, 47, 48, 61, 64, 65, 67, 68, 89, 127, 176, 179.
— creeping, 4, 9, 16, 23, 24 (fig.), 30 (fig.), 70, 82 (fig.), 95, 126, 127, 156, 162, 163, 164, 183, 186, 211.
— marsh, 66, 86, 211.
— milk, 4.
— musk, 150, 156, 167. See also *Carduus nutans.*
— spear, 86, 128, 167, 211.
— stemless, 65, 211.
Thlaspi arvense, 17, 115, 224.
Threshing machines, 15, 45.
Thyme, 94, 178.
Timothy, 75.
Toadflax, 21, 31, 146, 147, 153, 157, 162, 163, 195, 215.
— round-leaved, 147, 148, 150, 157.
Toadstools, 182.
Tomato, 97.
Tor grass, 69.
Tormentil, 104, 198, 220.
Tragopogon porrifolius, 73.
T. pratensis. See Goat's-beard.
Trailing weeds, 87.
Transport of impure seed, 10.
— weeds distributed by, 10.
Transvaal, weeds, 43.
Trefoil, 166.
— bird's-foot. See *Lotus corniculatus.*
Trifolium, 75.
T. angulatum, 44.
T. arvense, 97.
T. dubium, 44.
T. filiforme, 97.
T. parviflorum, 44.
T. pratense, 97, 119.
T. procumbens, 44.
T. repens, 97.
T. striatum, 97.
T. strictum, 97.
T. subterraneum, 97.
Triticum repens—Agropyron repens, 225.
Tuber, 38.
Tufted weeds, 87.
Turnip crop, 51.
Tussilago farfara. See Coltsfoot.
Twitch, 47, 48, 49, 127, 132.

UBIQUITOUS weeds, 123, 125.
Ulex europæus. See Gorse.
Underground stems, 9, 31, 46, 86, 88, 104, 111.
United States, 4, 114.
Urtica dioica, 129, 179, 188, 194, 203, 225. See Stinging Nettle.
U. urens, 179. See also Small Nettle.

Vaccinium uliginosum, 195.
Valerian, common, 73.
Valeriana officinalis, 73.
V. dentata, 73.
V. olitoria, 146, 147, 158, 225.
Vegetative reproduction, 18, 31, 86.
Verbascum thapsus, 73.
Vernal-grass, 182.
Veronica agrestis. See Field Speedwell.
V. arvensis. See Wall Speedwell.
V. chamædrys. See Germander Speedwell.
V. hederæfolia. See Ivy-leaved Speedwell.
V. serpyllifolia. See Thyme-leaved Speedwell.
V. tournefortii, 81. See also Large Field Speedwell.
Vetch, common, 73.
— horse-shoe, 17.
— kidney, 187, 208.
— narrow-leaved, 21 (fig.), 226.
— tufted, 17, 18, 226.
— wild, 11, 20, 90. See also *Vicia sepium.*
Vetches, 50, 53, 58.
Vetchling, 58.
Vicia, 20. See also Wild Vetch.
V. angustifolia, 21 (fig.), 226.
V. cracca, 17, 18, 226.
V. hirsuta, 226.
V. sativa, 73, 226.
V. sepium, 226.
V. tetrasperma, 226.
Viola tricolor. See Field Pansy.
Viper's Bugloss, 104, 212.

WATER culture experiments, 5.
Watercress, 11, 178.
Water dropwort, hemlock, 73.
Water grass, 47. See also *Agrostis.*
— logging, 66, 118, 133, 177.

Water plants, 178.
Weed communities, 117, 120, 124.
— flora, introduced or alien, 4, 11.
— — of gateways, 16, 183.
— — — paths, 183.
— — — rick sites, 185.
— — — shady places, 177, 185, 186.
— — — trodden places, 183, 184.
Weeds harmful to farm products, 112-116.
— — — human beings, 103-12.
— — — live stock, 103-12.
Wheat, 5, 6, 7, 52, 58, 70, 102, 105, 112, 114, 160-74.
Willow-herb, 23, 25 (fig.). See also *Epilobium spp.*
Willow-weed, 66, 70, 76, 117, 131, 133, 151, 157, 169, 188, 220. See also Persicaria.
Wind, weeds distributed by 17, 21.
Winged fruits, 21, 22 (fig.).
— seeds, 21, 22 (fig.), 99.
Woad, 194.
Woburn Experimental Station, 53.
Woodwax, 35 (fig.), 37, 66, 115, 176, 179, 188, 194, 214.

Yarrow, 17, 28, 115, 128, 151, 179, 182, 188, 206.
Yellow Rattle, eradication, 99.
Yorkshire Fog, 2, 27, 44, 176, 179, 185, 215.

PRINTED IN GREAT BRITAIN BY THE UNIVERSITY PRESS, ABERDEEN

14 DAY USE
RETURN TO DESK FROM WHICH BORROWED

LOAN DEPT.

This book is due on the last date stamped below, or on the date to which renewed.
Renewed books are subject to immediate recall.

21Jan'65SS

REC'D LD
JAN 15'65-12M

SENT ON ILL

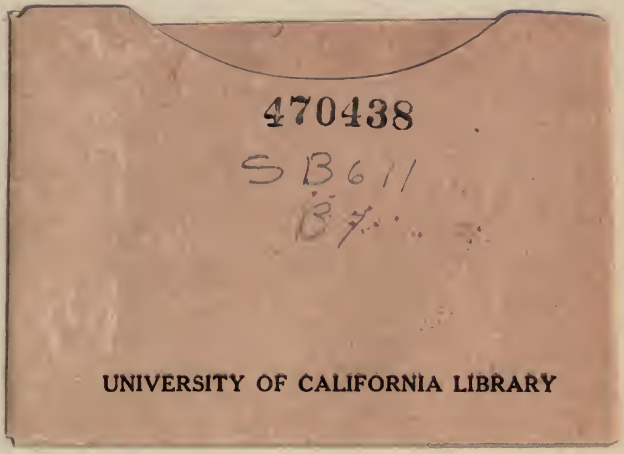
SEP 25 1998

U. C. BERKELEY

LD 21A-60m-4,'64
(E4555s10)476B

General Library
University of California
Berkeley

YC 58804


470438
SB611
B7...
UNIVERSITY OF CALIFORNIA LIBRARY